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REON

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ROCKET ENGINE OPERATIONS – NUCLEAR

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Informal Monthly Progress Letter No. 24

to

AEC-NASA SPACE NUCLEAR PROPULSION OFFICE

for

NERVA PROGRAM

Contract SNP-1

(U)

Letter Report No. L0560-10-24

Covering Period of June 1963

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RESTRICTED DATA - ATOMIC ENERGY ACT 1954

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I. INTRODUCTION

This document is the twenty-fourth in a series of informal monthly letters reporting progress of the NERVA engine development program and its associated tasks, and is submitted in partial fulfillment of AEC-NASA Contract SNP-1. This document covers the month of June 1963, and is the ninth monthly report to be submitted during NERVA Contract Year 1963 (1 October 1962 through 30 September 1963).

Work performed in each reporting period is discussed by task item number as defined in the contract. In order to restrict the amount of material presented to a convenient quantity, the intent is to include in each monthly report only that discussion which is required to provide the reader with a concise summary of the work performed. In general, detailed technical information, lengthy theoretical derivations, and extensive data tabulations have been purposely omitted. These details will be provided as appropriate in special technical reports.

This document is the result of combined input data from REON; Westinghouse Astronuclear Laboratory; The Bendix Corporation; The Bendix Products Aerospace Division; AMF Atomics, a Division of American Machine and Foundry Co.; and Liquid Rocket and Downey Plants of Aerojet-General Corporation.

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II. SUMMARY

Work proceeded during the reporting period in accordance with Contract SNP-1, Supplement II to Appendix B, effective 1 May 1963.

Additional work authorized to proceed in advance of receipt of C.O. No. 1 to Mod 8 was begun. This consisted of the initiation of procurement of cameras, light sources and associated fixtures to be used in connection with the reworked NRX-A nozzle during the conduct of NRX-A tests. A round trip shipping demonstration of a dummy core by special train shipment was completed to obtain environmental data on acceleration and shock loads.

In order to ensure that the future test efforts at NRDS on the NRX-A1, -A2, and -A3 will be monitored properly, an NRX-A1 Task Force has been established. This group has been charged with the continuous review of critical areas including design, fabrication, assembly, test planning, and NRDS operation. The Task Force will monitor areas appearing to affect test schedules, and establish causes of any possible delay in the test schedule. Corrective action will be determined so that the test schedule may be re-established and maintained without further delay. In addition, the Task Force will recommend to NERVA program management any action which should be taken to correct possible schedule delays and/or the establishment of new schedules. Schedule changes will be coordinated among the various program participants. The membership of the Task Force will consist of a senior representative from REON, LRP, WANL, NTO, and SNPO-C.

A somewhat similar group, the Nozzle Task Force, has been formed to resolve the nozzle casting problems. Principally, the nozzle casting problems consist of obtaining the required physical properties for the nozzle castings, particularly elongation of the nozzle jacket. Acceptable quality castings have been obtained with respect to the ultimate and yield strengths. To date, acceptable elongation properties have not been obtained. Elongation values in the range of 6 to 8% are desired, while values of 2 to 4% have been obtained.

Nozzle casting attempts at Pacific Brass Co. have been terminated for the time being. Instead, castings will be fabricated at the LRP foundry. This foundry presently uses a casting metal (Aluminum A-356) in Titan pump housings

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which has demonstrated the capability of providing the elongation rates required for the NERVA nozzles. Additional nozzles will be cast at the Howard Foundry in Chicago. This foundry claims to have the capability to produce acceptable quality castings with the desired elongation.

A second concept, involving all steel U-tube nozzles, is being expedited as an alternate approach to the solution of the nozzle fabrication difficulties.

Initial actuation tests were conducted with the first Configuration II TSOV. Satisfactory operation resulted. Work will now begin with the conducting of operational and environmental tests.

A successful test was conducted of the Mk III Mod 3 TPA at near FX power and under hot turbine gas conditions (excess of 1200°R).

Design work proceeded on the conceptual layout of the Mk IV Mod 2 TPA which includes provisions for sealing the pump. This re-direction was specified by SNPO-C in order that only minor TPA revisions would be required in the event that it became necessary to accomplish a "wet pump" start-up.

Qualification tests of the NRX-A reactor shipping container have been completed. The test results indicate that the shipping container satisfies all specification requirements.

Fabrication testing of the 9-inch B4 fuel element lengths suspended in the lateral support system (NRX-A1 Single Coil Springs) has been completed.

Modifications to the building at the WANEF site, where the reactor critical experiments will be conducted, have been completed.

The analytical and experimental work on the hydrodynamics of the emersion of a NERVA core in water has been completed.

Documentation submitted during the reporting period is summarized under Sub Task 4.3, Additional Documentation.

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SECTION III

TECHNICAL DISCUSSION

TASK 1.0 ENGINE DEVELOPMENT

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Item 1.1 **ENGINE SYSTEM**

A. **SUB-SUBTASK 1.1.0 - ENGINE SYSTEMS INTEGRATION, MECHANICAL DESIGN, AND DOCUMENTATION**

1. E-Block I - Engine Design

Work continued on an interface control drawing for the control drum interfaces with the pressure vessel and the actuator envelope configuration. Problem areas include space requirements needed to facilitate engine assembly-disassembly operations, and limited availability of design information for the G.E. actuators and amplifier hardware.

Revisions to Drawings 089507, Block I, Engine Assembly, and 088255 Block I, Engine Installation, are 50% complete. In addition to the relocation of the turbine exhaust and propellant feed lines, a check valve and bellows was added to the pump discharge line in conformance with recent systems information.

Design effort continued on an interface control drawing to establish the remote disassembly-assembly sequences for the E-Block I Engine. Subsystem design and development activities are being coordinated and used to establish a basic mechanical configuration compatible with current handling equipment design information.

In accordance with program commitments to revise FX Engine Model Specification AGC-10095; design changes were completed for the following drawings:

a. 086864, Hot Bleed Installation, FX Engine

b. 086865, Hot Bleed Assy, FX Engine

c. 089649, Schematic Controls and Flow Diagram

d. Engine Orientation Diagram

Revision "F" of the Planning Parts List for the hot-bleed NERVA development engine is in process and will be issued during the next report period.

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2. Interface Gages

Current fabrication schedules for the matchplates and master gages indicate that they will be delivered to WANL by 31 August. Design and fabrication rework change requests for matchplates and master gages have been issued by LRP to comply with the new NRX-A2 P.V. design. As a result of verbal discussions with the fabrication vendor and WANL representative, early August delivery of the shield-to-reflector-to-P.V. matchplate, and the cylinder-to-closure matchplate, was considered feasible.

3. Specifications and Documentation

a. FX-Engine Model Specification

Effort on Revision D of the specification was completed and it will be issued on schedule.

b. Engine Systems Data Book

Information and data for updating the model specification will be incorporated in the next revision of the Data Book.

B. SUB-SUBTASK 1.1.1 - GENERATION II ENGINE SIMULATOR

The Final Report on the Generation II NERVA Engine Simulator (REON Report 2543) was issued during this period. This completes all effort on this project.

C. SUB-SUBTASK 1.1.2 - COLD FLOW DEVELOPMENT TEST SYSTEM (CFDTS)

1. Design

Drawings of the unique hardware are nearing completion, except for the turbine inlet line which is being redesigned as a result of the change in diluent extraction location. The Sequence Assembly Plan drawing is 50% complete, and study of the assembly handling and transportation of the CFDTS is continuing. The pressure vessel assembly drawing is 80% complete. Effort continued on the conceptual design of the propellant supply line from the H-5 tank to the CFDTS tank shut-off valve.

2. Fabrication

Fabrication orders were released for standard hardware for the thrust structure assembly.

3. Test

Effort was continued on revisions to the preliminary test plan. At a meeting with WANL the instrumentation measurement requirements list was coordinated. It was confirmed that the nuclear instrumentation would be based on the NRX-A1 instrumentation.

D. SUB-SUBTASK 1.1.6 - ENGINE SYSTEMS ANALYSIS

During this report period the systems analysis work effort was continued with analyses of the NRX-A, CFDTS, and E-engine systems. A listing of the WANL systems analyses was received and incorporated into the overall NERVA systems analysis program. Agreement was reached with WANL on responsibilities related to the various systems analysis efforts, and this will be submitted to SNPO-C for approval as part of the overall system analysis program.

During the report period, the following work effort was accomplished under the system analysis program:

1. Steady-State Analysis

The nuclear engine analysis program was used to establish the turbine inlet line orifice size. A tentative selection of an orifice was made and a new set of operating conditions was calculated. The program has also been used with data for the Kiwi-B-2 core to determine system performance. Because of the lower core pressure drop, higher performance is obtained. Several runs were made to establish the NERVA engine growth potential. The program was modified to allow use of a new nozzle heat transfer coefficient. Runs will be made to determine any change in system performance which results.

A modification of the nuclear system analysis program is being made to allow analysis of the NRX-A system. This involves removal of the closed-loop provisions in the current program.

New schematics were issued for the FX engine, the E-1 test conditions at 70% power, and the E-1 design conditions. Several performance curves were prepared for inclusion in the engine model specification.

The program used to determine core fuel element and tie-rod flow distribution and temperatures is being used to determine the required orificing for equal fuel-channel temperatures at design conditions.

A nozzle transient analysis was made of tube and cast aluminum jacket temperatures for the LOX-H_2 simulation tests. Other runs will be made to determine the temperatures and thermal gradients in the nozzle jacket under various operating conditions.

A component analysis code, written to predict component limiting temperatures and pressures is being modified for inclusion in a reactor-kinetics code presently under preparation.

Checkout continues on a bottom support plate subroutine intended for inclusion in the nuclear engine analysis program.

A relaxation network analysis of the Kiwi-B-2 lateral support temperature distribution is being continued. A detailed thermal analysis of the Kiwi B-2 rocker arm assembly is also being made.

2. Transient Analysis

a. NRX Dynamic Analysis

The results of the analog computer program on the Kiwi B-4 control system, which was run in May, indicated a stable operation of the NRX-A reactor in the 1% to 100% power ranges. Improvements were incorporated in the reflector model and the NRX core model. The revised analog problem, including the latest changes, is in process on the computer. Present indications are that the previous results obtained in May are still valid.

A computer model of a gas mixing chamber is being developed. The chamber is to be supplied by LASL to provide single-phase cryogenic temperature gas for the NRX-A tests. The model is now on the computer for debugging. The gas mixing model when combined with the feed system model, will duplicate the conditions LASL is using at the Test Site to test the mixing chamber.

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b. Power Range Simulation

(1) Analog Computer Program

Power range startup runs were made using the analog computer for a variety of chamber temperature rates from 90°R/sec to 150°R/sec. These start-up runs were analyzed and used to generate startup transients of thrust, total impulse, and specific impulse.

The analog engine model was then updated to the latest design specifications. This includes the incorporation of the latest diluent bleed point, and the latest design point parameters. The analog equations involved are being compiled for REON use.

The power range startup transients are being rerun to determine the effects of the most recent computer model charges on those results encountered earlier.

(2) Linear Analysis

The linearization was completed for the current equations used in the power range analog simulation. Time constants and gains for the transfer function in the NERVA Engine were obtained in a generalized form in order that numerical values for the different operating points could be calculated without repeating another linearization of the system equations. Time constants and gains were calculated for the design point values in the system.

Constants will be calculated for a number of different power levels as the next step of the linear analysis. Then, an analysis will be made at different system operating levels to determine the effect of the nonlinear characteristics of the system.

The results of the analysis will be used to check the dynamics of the solution of the analog computer. More importantly the results of this analysis will give a rational guide to update the compensation circuits currently being designed for the controllers.

(3) Reactor System Dynamic Analysis

The WANL hybrid reactor core model has been revised for compatibility with the HYDAC computer at Electronic Associate's Princeton Computation Center. Arrangements have been made for initial development studies of the hybrid core model on the HYDAC computer.

An analog simulation of the pressure-enthalpy-temperature relations of hydrogen is being developed. This will be used with the hybrid reactor core model. Basic concepts are being investigated for feasibility.

An evaluation is being made of signal generators for use with cross-correlation methods for the measurement of the transfer functions of a reactor.

c. Cooldown

Data taken from the cooldown analog computer model are now being prepared for distribution in a technical memorandum. These data concern probable control schemes for the first 500 seconds of cooldown in the NRX-A engine.

The model is now being prepared for incorporation into the full power analog analysis, but with the retention of continued cooldown analysis capability. Additional cooldown analysis will be delayed until the receipt of cooldown nuclear heat generation data for NRX-A. This is currently being provided by information from Kiwi B-4 tests.

d. CFDTS Transient Analysis

The Cold-Flow Development Test System equations were re-examined for the effects of substituting copper or aluminum for the usual core materials. It was found that the changed thermal diffusivity would not be important, but that a changed total heat capacity could be quite significant.

3. Data Analysis

A 7094 digital program (LRP NERVA data package) for automatic analysis of the CFDTS slow channel (narrow band) data was written and is being debugged.

Information was obtained on the digital tape format used by LASL for their data from NRDS Test-Cell A. A copy of the digital data tapes from the Kiwi B-4A hot firing (E.P. VI) was obtained for data analysis technique development. A program is being written to rearrange the data to be obtained from the NRX-A1 cold flow test to a format which can be analyzed by the LRP NERVA data package. The B-4A hot firing data will be used to check out the planned analysis.

A time series data edit program was written and is being debugged. This program will edit test data to locate and correct outlying or spurious data points. In addition, the program provides a means for optional smoothing of the test data as well as a listing of data points that were corrected.

E. SUB-SUBTASK 1.1.7 - INTERFACE MOCKUP

Final issue of the test plan for the pressure vessel closure interface mockups was postponed until July due to the addition of a shear-lip in the design.

F. SUB-SUBTASK 1.1.8 - NRX-A INTEGRATION AND DOCUMENTATION

1. Design Integration

a. NRX-A Assembly

The NRX-A Final Assembly drawing (REON Drawing 092349) is nearing completion, and will be released on schedule.

b. Test Car Installation

The test car assembly drawing is being prepared by WANL and is approximately 95% complete. Current plans are to release it during the next report period. Fabrication of components is progressing on schedule. A re-evaluation of the instrumentation boom design is being conducted. Results of the study are expected in thirty days.

The test installation drawing (RECM 092346) was delayed, pending receipt of the test-car assembly drawing and other instrumentation assembly drawings.

The propellant supply line interface drawing (RECM Drawing 091256) was revised to include instrumentation bosses and will be issued during the next report period.

The instrumentation assembly drawing (RECM Drawing 284644), showing the diagnostic instrumentation on the pressure vessel and nozzle, has been revised to include the latest instrumentation requirements. It will be released by 30 July.

G. SUB-SUBTASK 1.1.9 - NERVA/RIFT COORDINATION AND DESIGN SUPPORT STUDIES

1. Interface Coordination

There were no meetings scheduled for the NERVA/RIFT Interface working group during the month of June.

2. Support Studies

Report No. 2585 evaluating proposed LMSC thrust-vector control system was completed and issued to SNPO-C.

Item 1.2 PROPELLANT FEED SYSTEM

A. PROPELLANT FEED SYSTEM ASSEMBLIES

Installation and interface control layout of the Mark-IV TPA, in the lower thrust structure, was redirected to the Mark-IV Mod 2 TPA configuration.

The MARF propellant feed system mechanical interface control drawing was started.

Drawings were completed presenting machining details, materials, proof pressures, proof temperatures, REON and vendor part numbers for the twenty-two remote Conoseal joints in the propellant feed system.

Delivery of Marman disconnect test cells for development testing has been slipped to 23 July.

A 1500-psi hydrostatic proof test was successfully completed on a 5-inch Marman remote joint.

A report was prepared outlining the results of the preliminary pump suction line water flow test.

Fabrication of the component development turbine inlet line was stopped; and a redesign of the line was initiated, based on the current plan of cooling the line with diluent extracted from the shield plenum inlet.

B. VALVES

The first Configuration II TSOV kit was completed. A configuration I TSOV was assembled, acceptance tested, and shipped to the Cryogenics Laboratory, for liquid hydrogen tests.

Fabrication of a TPCV piston-ring test fixture was completed and tests were conducted on two rings fabricated from Hastelloy-C. The rings were installed in the piston-ring test fixture and placed in an oven for 5 minutes. The piston rings were dimensionally inspected before installation and after removal from the test fixture. There was no evidence of any loss in spring rate or permanent distortions due to the elevated temperature.

Ambient temperature internal-leak tests were conducted on the stainless steel Configuration II TPCV. The valve gate was cycled open and closed 800 times. Leakage past the piston rings averaged 2.1 scfm with 25-psig gaseous nitrogen applied to the inlet. Subsequent tests were conducted to determine the leakage between the piston ring and body bore. This leakage was determined to be 1.5 scfm of gaseous nitrogen.

Leakage tests with LH_2 were conducted at the cryogenic laboratory using a stainless steel primary seal and seat in the cooldown-valve test cell. The results indicated that the primary seal remained bubble-tight at liquid hydrogen pressures up to 25-psig. A 50-psig gaseous-helium leak test was conducted after the test cell had warmed to ambient temperature. The primary poppet seal remained bubble-tight.

A stainless steel poppet seal and seat underwent a functional and leak test, using the cooldown-valve test cell. Testing was conducted using gaseous helium cooled to liquid nitrogen temperatures. 50-psig leak-tests were run at various intervals during the 370 poppet actuations. Leakage averaged less than 2-cc/min during the ten leak-tests conducted. Inspection of the seat and seal following the test disclosed no deterioration of either the seat or seal. Analysis of the test results is being continued.

C. TURBOPUMP ASSEMBLY

The basic TPA test plan was brought up to date by amendments published during this report period. In addition, a preliminary specification was completed delineating TPA inspection instruction, disassembly inspection instruction, new hardware component dimensional records, and final hardware component dimensional records.

A Mark III Mod 3 TPA (S/N 0000006) was assembled and tested on Run 1.2-08-NNP-003. The object of this test was to evaluate the turbine under hot turbine conditions. The test was successfully completed for a total duration of 71.4 seconds. Post-test disassembly revealed some melting of the leading edge of the second stage rotor buckets near the tips. This was attributed to blame holding at the second stage nozzle exit. Test setup

modifications were initiated to prevent oxygen concentration. Changes made included the addition of a plenum mixing chamber to the gas-generator system, and the inclusion of an O_2 line purge to insure the elimination of any shutdown temperature spikes.

The design engineering effort on the Mark IV turbopump was redirected to conceptual design activity on the new wet-pump concept. This Mark IV Mod 2 concept includes provisions for a lift-off seal in the power transmission at the turbine interface, and dual fluid seals on all external joints. As a result of this redirection, new schedules and mileposts for the Mark IV Mod 2 will be established.

Assembly of TPA, S/N 0000005, is nearing completion. This TPA employs the pinned second-stage nozzle, integral labyrinth, and Armalon bearing cages in all positions.

D. BEARINGS

A bearing test plan was completed. The first, and backup, bearing choices for demonstration of the contract year mileposts were selected and presented in this plan.

Three bearing tests (1.2-04-NNW-016, -017, and -018) were conducted in the turbine tester during this report period. The first was aborted due to LH_2 line contamination from the test stand. The second was performed to evaluate a new ITI close-clearance thrust bearing geometry with an Armalon thin-line cage. Post-test inspection of the bearing after 8.2 minutes of operation at 2000 pound load showed inner race distress due to a brittle fracture at the ball-rolling track.

The third test was performed primarily to evaluate a 16-roller thin-line Armalon caged roller bearing for the turbine and position. After 9.0 minutes of operation at 2000 lb load and 16,000 rpm, this bearing remained in excellent condition. The development of non-metallic, caged, roller bearings was previously considered to be very difficult due to low cage strength at the thin sections between the rollers. A 14-roller bearing with a similar Armalon thin-line cage

was run in the slave (unloaded) position of this third test. The cage pockets of this bearing were moderately burned, and the surfaces of the rollers had a dull blue-stained appearance, while the rollers of the loaded 16-roller bearing were bright. This indicates that an unloaded condition may be more severe than one with a 2000-lb load.

The electric-motor tester was run at 3000 rpm for one minute in the Cryogenics Laboratory as a checkout of the electrical power supply system. Flow tests were made on the pneumatic-bearing loading system. Difficulties in pneumatic-bearing loading encountered during this test are being defined and corrected prior to high speed testing.

Item 1.3 NUCLEAR SUBSYSTEMS

Item 1.3.0 INTEGRATION AND TECHNICAL MANAGEMENT

A. NRX-A DESIGN AND COMPONENT DEVELOPMENT PROGRAM REVIEW

A design review of the NRX-A reactor was initiated to determine:

Critical areas in the present design,

Possible modes of failure for each component or subassembly,

Redesign or corrective action if required,

Additional tests required to evaluate possible modes of failure.

Preliminary results of the design review are on file in the REON office.

The design review effort will continue in coordination with WANL. Interim documentation will be prepared as necessary.

In conjunction with the design review, a review of the component test program was conducted to determine

Tests required in support of NRX-A1 and A2,

Adequacy of planned tests,

Whether test schedules can be met in sufficient time to be of value to the NRX-A series

Requirement for additional tests.

Preliminary results of the component test program review are on file in the REON office.

It is planned to continue this effort during the next month in coordination with WANL. One of the objectives of the continuing effort will be to assign priorities to each of the tests outlined in the WANL component test program.

B. REVIEW OF NRS-A SYSTEMS TESTS

The WANL definitions and objectives for the proposed NRX-A1, 2, 3, and 4 systems tests were reviewed, in conjunction with the design review, to

determine whether the sequence of individual tests adequately covered the objectives of the Block-I tests. Alternate test objectives were discussed to determine a more suitable sequence of tests for arriving at a reactor operation which would confirm a suitable engine development design.

Preliminary results of the test review are on file in the REON office.

Item 1.3.1 NUCLEAR SUBSYSTEM
REACTOR MECHANICAL DESIGN

A. NRX-A REACTOR

1. Outer Reflector Assembly

Design layouts of the outer reflector and control drum assemblies were updated and released.

Drawings defining a new spring retaining bolt and locking device, required to center the safety spring, were released for incorporation in NRX-A1.

Work is continuing on instrumentation modifications to detailed parts of the NRX-A1 and NRX-A2 reactors. All information pertaining to control-drum instrumentation modifications for these reactors has been released.

Tests conducted at the vendor's plant showed that the first set of control-drum couplings and drive shafts have the capacity to absorb the specified misalignment.

An order has been placed to develop "Magneforming" techniques for dimpling the control-drum housing so that the control plate can be spaced more simply. This would be a back-up design to the present rivet-spacers. In addition, "Magneforming" is being investigated as a method of sealing and joining the bearing-shaft extension to the housing. Samples have been received and are being strength tested.

2. Inner Reflector

Detail layouts showing an integral aluminum barrel retention device for the NRX-A1 reactor were completed and detail drawings of the detent cup and spring were released. The drawings of the inner reflector cylinder and aluminum barrel have not been altered to receive these parts pending review of the feasibility of adding the tabs to the NRX-A1 nozzle.

Detail layouts of the inner reflector cylinder area and aluminum barrel were updated and released.

A satisfactory anti-galling coating appears to have been found for the titanium bolts which fasten into the titanium reflector support. A nickel plating, applied in accordance with the "Kanigen" process followed by a silber plate, works successfully in cryogenic and room temperature tests.

Low (approximately 1%) elongation values were recorded in test welds of the aluminum support barrel when welded in the T31 condition and then aged to T81. A revised heat treatment was therefore specified calling for a re-solution treatment of the barrel, after all welding, to the T42 condition, followed by an aging to T62. Test samples run through this treatment have given excellent results, with an elongation of approximately 8%.

The following study layouts have been released:

a. Screw, Locking Device, Lateral Support

Various methods are proposed of preventing the lateral support screws from loosening because of vibrations. One method which appears very satisfactory is to crimp a thinned-down portion of the bracket into scallops in the head of the screw. Models of the more promising devices are being made for visual and test evaluation.

b. Controlled Flow Core Seal

This layout investigates methods of axially grooving the lateral support seal segments to provide a controlled leakage past the seals in order to cool the filler strips. Preliminary thermal calculations indicate that the 60% ratio (of cooled filler versus total filler circumference) might be adequate, proviced that it applies to each filler strip. A fixture and tooling are being designed which will make it possible to modify the segments in-house in accordance with final calculations.

c. Key, Core Assembly Barrel and Inner Reflector Cylinder

An aluminum locating key is provided on the ID of the aluminum barrel to insure the alignment of the coolant hole slots with the reflector cylinder coolant holes. The key is riveted to the barrel after aging and engages a groove in the inner reflector cylinder. Detail layouts and drawings are in work for this item.

d. Cylinder, Inner Reflector Repair Study

Raw material cylinders may contain voids which require repair or plugging to be useful. This layout investigated various plug configurations which could be inserted once the defect is removed. The advantages of each method will be reviewed, after samples are tested, to determine the most adequate design. Each repair plug on a cylinder will have to be considered individually since its location and size will be influencing factors.

A tentative general repair specification has been written. This specification, which covers the procedure to be used when repairing cylinders, will be applied on an individual basis after a thorough review of each defect.

3. Core Subassembly

a. Filler Strips

A specification change has been processed to substitute Armstrong C-7 cement, an epoxy resin, in place of Duco to bond one end of the tile to the filler strip. The other end is still bonded by National Carbon P-514 cement.

b. Dome End Seal

A detail drawing to modify the dome end seal fingers has been released. This revision changes the seal finger angle from 29 to 50° in order to facilitate reassembly of the support plate to an eccentric bundled core.

A mockup of the dome end seal has been completed and a mockup of the forward end of a bundled core has begun. These parts will be used to help evaluate possible removal and re-installation problems and the general adequacy of the design.

c. Fuel Elements

A change is being processed to increase the depth of the coating undercut at the nozzle end of the elements in all flow tests. This change provides a channel which will help equalize pressures at the exit end of the elements.

Drawings have been released defining the elements which are required for the component test program: coated natural uranium element, uncoated natural uranium element, and unfueled coated element.

A limited number of the unfueled coated elements will be incorporated into the NRX-A1, Phase I Vibration and Plugged Core tests in order to evaluate interfaces of coated surfaces.

d. Tie Rods

Difficulties in upsetting the head and thread ends of Inconel X-750 tie rods have been related to large grain size which results from the heat treatment specified. Specification revision designed to prevent this problem is in work. Concurrently, tie rod forming has begun on newly-received fine grained material.

e. Support Blocks

A design change has been processed to remove the small alignment sleeves from the support block assembly. The blocks for the NRX-A1, NRX-A2 and Plugged Core reactors will be coated without the sleeves being installed.

f. Cluster Assemblies

The seven irregular fuel cluster assembly drawings for the NRX-A2 have been released, based on the core periphery redesign and on the latest distribution of fuel loadings.

g. Cluster Plates

Sample cluster plates were made from several blanks of silver-indium-cadmium (80, 15, and 5% respectively). This material exhibited

very good machinability characteristics and adequate strength for this particular application.

Gadolinium-304 stainless steel will be the backup material. The two vendors for gadolinium stainless steel have encountered difficulty in making heats of this material of any appreciable size (over 20 lb) and maintaining the required gadolinium content of 0.8 to 1%; consequently investigation is being made of a second alternate backup material such as Type 304 stainless steel, with approximately 1% B-10 added.

h. Orifice Jet Assembly Cement

Tests have been completed to evaluate six candidate cements for bonding of the orifice jets into the fuel elements. Leak rate tests were run, both at room temperature and at temperatures approaching the cryogenic range, to determine the sealing characteristics. No tests have been conducted of elevated temperatures, and the effects of irradiation have not been determined. The best candidate appears to be a cement containing Teflon, which exhibited the lowest leak rate, expressed in a ratio of leak pressure/applied pressure.

j. Instrumentation

The detail drawing which defines instrumentation modification for the Phase I Vibration Reactor Core Support Plate was released.

Drawings of filler strips modified for strain gage instrumentation were completed.

A detail layout for instrumented NRX-A1 inner reflector components has been completed. Detail modification drawings for the inner reflector cylinder, metal barrel and spring support ring have been completed and released.

A "breadboard" model of the upper support plate, showing mounting locations for transducers and other instruments, is being used to establish optimum transducer locations.

The layout of the NRX-A1 core instrumentation is nearly complete.

For instrumentation routing out of the reactor, the NRX-A1 will use all nine instrumentation ports, plus two which were not used for operating drums. One of the ports that has been reserved for shield instrumentation will now be used for core instrumentation requiring special stalk adaptors.

Pull tests were made on a potting compound for thermocouple leads at both ambient and cryogenic temperatures. Tests were initiated to determine the relative strength of the potting compound to be used in installing the instrumentation, and to determine the effects of thermal contraction on the strain gages and leads.

4. General

Work continued on the following special projects:

a. Effort directed toward keeping weight and balance calculations current.

b. Work designed to establish the procedures for adding unit moments to IBM printout. This task will set up a procedure for translating center of gravity for each part to the center of gravity for an assembly, which will be translated into a reference axis.

c. Initiation of an instrumented parts list for NRX-A1.

d. Testing external wrenching bolts, along with the Class "A" locking devices, to establish acceptable design. With minor modifications to the bolt shoulder and locking device cup, the design is acceptable for its intended use. Twelve-point external wrenching bolts are being incorporated on the instrumentation stalks, core support ring, and control drum bearing housing.

The report Effect of Tie Rod on the NRX-A Core Lateral Deflection, WANL-TME-392, was completed. This is an analysis of the "pivot" effect of the tie rods on the core deflection during a lateral acceleration. The results

shows that the maximum displacement at the nozzle end of the core is approximately 6% (or 0.012-in.) greater when the effect of the tie rods are considered.

Calculations on the NRX-A core peripheral seals indicate that the pressure drop is not sufficient to seat them, assuming they are unseated at start-up. These calculations indicate that if the coefficient of friction is 0.2 and the core is at room temperature, 17 psi is required to seat an unseated seal. Therefore, since only 141 psi is available at steady state (or 8.3 psi per seal) there is no assurance that all of the seals will seat. By modifying the design to have a 30° angle on the lateral support plunger pins, all of the seals can be seated against the inner reflector ledge at room temperature.

An analysis indicates that the inner reflector hold-down springs could be designed to exert a larger force. This would not only reduce the tensile stress in the inner reflector that may exist due to the radial temperature gradient, but also reduce the possibility that the inner reflector may lift from the nozzle.

Stress reports on the fuel elements, tie rods, dome end flange of the outer reflector support structure, and pyro tube are in process.

Analyses are in progress covering the possibility of unseating the inner reflector, and the effect of the tie rods on element separation due to the absence of an inlet band.

5. Miscellaneous

a. Assembly Stands and Fixtures

Bundling fixture and filler strip gage designs were released. These devices will permit bundling of the core with simulated lateral support pressures.

The measuring fixture design was released. This fixture, in conjunction with the bundling fixture and filler strip gages, will serve to measure the deviation of the filler strip from a right circular cylinder. These

deviations in turn will be used as a guide in machining the filler strips so that upon assembly with the elements the core will be a right circular cylinder.

b. Shipping Containers

Qualification tests of the MRX-A reactor shipping container were completed by the vendor. The test results show that the shipping container satisfies all of the specification requirements. Complete photographic coverage of the test operations was provided. The qualification tests were conducted with the instrumented dummy reactor installed in the container and were as follows:

(1) Impact Test

The container was installed on a railroad flat car with the normal transportation mountings and tie-downs. The car was placed in motion in such a manner that it struck the forward coupling of three stationary coupled cars at a velocity of 10 ft/sec, or 7 mph. The transportation vehicle received a railcar "humping" load or equivalent, and this input was attenuated by the container to within the specified values of 2.5 g vertically and 1.8 g laterally.

(2) Vibration Test

The container and installed dummy reactor were secured on a trailer vehicle and hauled over "rough" road beds. It was shown by instrumentation records that the full range of truck transportation frequencies (1.5 to 7.5 cps) were attenuated by the container to within the specified range of acceptability.

(3) Flat Drop Test

The container, with dummy reactor installed, was raised and allowed to fall freely from a height of six inches to a concrete surface, landing flat on its base. Instrumentation records indicate that the load input to the reactor support flange was attenuated to within the specified range of acceptability.

[redacted]

(4) End Drop Test

The container and installed dummy reactor were supported at one end of the base, on a sill placed at right angles to the skids and approximately five inches high. The other end of the container was raised and allowed to drop freely a distance of six inches to a concrete surface. It was shown by instrumentation records that the load input to the reactor support flange was attenuated to within the specified range of acceptability.

(5) Leak Test

The sealed container, with dummy reactor installed, was leak tested with the relief valve blocked off. A 15 psig air test was used in conjunction with standard soap solution technique. No visible leakage was noted.

All of the above tests were more severe than any anticipated occurrence during transportation of the reactor.

(6) Conclusions Derived from Tests

Based on these tests and additional tests which are fully described in the design report (WANL-TNR-116) it is concluded that the container design completely satisfies all design criteria and special requirements. The container was delivered to WANL on June 20, 1963.

(7) Shipping Poison Wire Retention Plate

Detailing was initiated on the design of a segmented shipping poison wire retention plate which will allow removal of the plate through the opening in the pressure vessel. This plate will provide for retention of the poison wires during control-drum checkout and will serve, in lieu of the previously considered cadmium strips, as a control drum override poison. The plate must be removed prior to the installation of the nozzle.

Work continued on the development of shipping poison wires. Difficulties were encountered in attaining the specified straightness and polyethylene coating thickness.

[redacted]
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6. Reactor Dynamic Analysis

a. Dynamic Characteristics of NRX-A Lateral Support System

The investigation of the dynamic characteristics of the lateral support systems was continued by the preparation of a report on the resonant and shock response characteristics of the NRX-A radial and tangential lateral support system.

An analysis of the LASL core wrapper concept was initiated, and a report on the resonant and shock response characteristics of this lateral support system is in process.

b. Core Element Interspace Flow Areas

The fuel element interspace gaps were recorded for a 60° sector core nine inches long, held in a simulated reactor lateral support system. A spot check of the gaps after the core was subjected to various vibratory load levels indicated that the gaps were unaffected by the vibration.

Detail drawings which describe aluminum filler strips and simulated partial elements have been completed and issued. These parts along with rejected grade elements will be used to assemble a core to be used in interspace geometry gap studies.

c. Parametric Investigation of Shock Capabilities

A report describing the parametric investigaton of the shock capability of the NRX-A core support system has been completed.

B. REACTOR SHIELD MECHANICAL DESIGN

Work continued on the design of the instrumentation for the aluminum shield replacement unit. Revisions required in existing drawings (layout, assembly, forging) to incorporate the instrumentation are also nearly complete.

C. EVALUATION AND DEVELOPMENT OF REACTOR NON-FUEL MATERIALS

Reported under Item 1.9.

D. MECHANICAL ANALYSIS AND TEST PROGRAM

1. A-1 Fuel Element Mechanical Tests

Test A1-1 Test data obtained from Oak Ridge elements show a dynamic modulus of elasticity of [illegible] x 10^6 psi for low stress values. Static bending indicated variances of Young's Modulus with the stress level. Values of E [illegible] x 10^6 at a [illegible]-psi stress level and 1.5[illegible] x 10^6 at a 400-psi stress level, have been obtained.

Test A1-[illegible] Several unloaded fuel elements (from Oak Ridge) were tested as cantilever beams in the A1-2-vibration test rig. Five elements were tested, and all failed at the clamped end, but with no indication of shipping or cracks at the free ends of the tested elements. Although the preliminary data is not conclusive, a typical result has some meaning: at 15 g boundary acceleration at [illegible] cps and .100-in. clearance, one element failed in approximately one second. A simplified analysis of the dynamic behavior of a fuel element vibrating under these boundary conditions was made. General formulas were derived giving bending stress as a function of the "g" loading, the clearance between the clamped end of the fuel element and the holding fixture, and the geometry and material properties of the element. At 30 g and with 0.050-in. clearance at the clamped end, the element touches, or flattens itself against the boundary for approximately 3/4 of its length, with a maximum bending stress of 15[illegible] psi.

2. A-2 Support Block and Insulating Parts Mechanical Test

Layout drawings of the temperature gradient rig are complete, and detail drawings have been started. The simulated lateral support rig has been fabricated.

3. A-9 Fuel Cluster Test

The detail drawings of the fuel cluster vibration test rig have been completed and procurement of the rig has been initiated. Test instrumentation has been ordered.

4. B-1 Lateral Support Spring Mechanical Test

The data from a test of eight lateral support helical spring assemblies indicate very little change in the relaxed spring length. The change in length after 37,000 cycles varied from -.07% to +.50%.

5. B-2 Laterial Support Block and Insulating Tile Subassembly Test

Fabrication of the test rig components for the current and back-up lateral support designs has been initiated.

6. B-4 Graphite Barrel Test

Test rig components and instrumentation for the permeability and buckling test of the graphite barrel have been ordered.

7. B-5 Vibration Test of Partial Core

A rough draft report of the properties and behavior of the solid core mounted in the lateral support system has been prepared and the final report will be completed by mid July, 1963.

Vibration testing of the 9-in. B-4 fuel element lengths suspended in the lateral support system (NRX-A1 single coil springs, k = 98.25 lb/in.) has been completed. The experimental data has been evaluated, and the results agree with the theoretical analysis and the previous tests of the solid core. The core elements did not separate for input vibration levels up to 20 g. At low frequencies, impacting of core and inner reflector was prevented by reducing the amplitude.

New springs (k = 1.6 lb/in.) have now been installed in the test set-up. This set-up simulates the Kiwi-B4A lateral support system. The natural frequency will now be below 5 cps. The test plan includes impacting of the barrel against the core in an attempt to induce fuel-element separation. High speed motion pictures will be taken of the core motion.

Drawings of the new NRX-A1 leaf spring (k = 137 lb/in.), partial, and related test fixtures have been completed and released for procurement.

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The partial length core of B4 fuel elements in the lateral support system (NRX-A1 single coil springs, k = 98.25 lb/in.) will be subjected to shock testing. These tests have been started.

8. C-2 Support System Test

Manufacturing and assembly drawings for the lateral load test rig have been completed.

Assembly drawings for the hydraulic power system have been completed. All of the components of the system have been received, and assembly is in process.

The design of the deflection measuring instrumentation of the core support plate was completed, and manufacturing drawings have been released.

9. D-1 Reflector Segment Mechanical Tests

Test D1-1 A test was conducted with a titanium bearing on titanium in a hydrogen environment at -320°F and +500°F. No serious galling resulted. The coefficient of friction was found to be 0.6. A second test with aluminum bearing on titanium was made at 500°F. The coefficient of friction increased with each cycle, changing from 0.32 to 1.05 after 6 cycles. The specimens were separated without difficulty; however, a layer of aluminum several mils in thickness remained welded to the titanium surface.

Test D1-2 A titanium bolt and nut combination was tested at low and high temperature in hydrogen gas with no evidence of galling. The nut was unplated and the bolt was successively plated with electroless nickel and electrolytic silver. Another bolt specimen (electroless nickel on electrolytic silver) was cycled to failure at ambient conditions to determine whether hydrogen embrittlement resulted from the plating process. The fatigue life was consistent with that of unplated specimens.

Test D1-4 The quick opening trip valve required for step input flow into the specimen was tested and functioned satisfactorily. Specimen testing will start as soon as a high-flow-rate pressure regulator is available.

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10. D-3 Control Drum Evaluation Tests

The environmental test chamber was evaluated for refrigeration loss and nitrogen gas flow characteristics. A flow of 3.0 lb/sec of liquid nitrogen was required to maintain a test temperature of -320°F. The chamber control drum actuation system was cycled and found to function satisfactorily.

Drawings were issued specifying the control-drum - drive-shaft torque measurement instrumentation and the drive-shaft modifications required to accommodate the instrumentation. Torque measurements will be accomplished by means of strain gages mounted on a reduced section of the drive shaft. Manufacturing drawings were issued for the test stand which will support the electro-dynamic shaker for the lateral vibration tests.

11. E-1 Reactor Assembly Mechanical Tests

All test fixtures for the core assembly test series, including mounting brackets, have been released for procurement. Test fixtures have been received for the adapters, the lateral drive rod, the torsional drive rod, and the support ring.

The complete reactor assembly test series fixtures are being detailed.

Modification of the 18 Oak Ridge core elements for the Phase I Vibration Reactor has been completed and strain-gage instrumentation attachment has been started.

a. Analytical Studies

Simplified analog models have been run for the lateral and torsional core assembly tests along with a shaker capability analysis. The analog models provide information on displacement and acceleration magnitudes which can be expected from the E-1 tests. The results indicate resonance points in the system occurring from 14 to 20 cps for input displacement of the inner reflector ranging from 0.04 to 0.8-in., peak-to-peak.

An acceleration level of 3.5 g can be imparted to the core with an input of 0.2-in., peak-to-peak. A 10,000-lb force is sufficient to impart maximum displacement inputs to the reactor from 5-30 cps. Above 30 cps the core is essentially vibration isolated.

In the torsional test, static friction is great enough to prevent the core from breaking away at input frequencies below the system natural frequency of 5.6 cps.

12. Component Tests

a. Support Ring Titanium Fatigue Specimen Tests

A plot of the number of cycles to failure as a function of stress amplitude was obtained for -320°F specimen temperature. For 0.30-in. thick specimens, the strength in bending was 250,000 psi for less than 1300 cycles. Chamfering the edges of the drilled holes in the specimen had little effect on the low cycle fatigue life. For the drilled hole pattern used in these tests, the stresses were negligible in the biaxial (lateral) direction as long as the deflection was within the elastic range.

b. Control Drum Bearing Tests

Friction tests of the irradiated poly-imide retainer ring specimens were performed, and the results were approximately the same as those obtained with non-irradiated specimens.

Two control drum bearings and a retainer ring will be irradiated in the Plumbrook Reactor. This test has been scheduled for August, 1963. The test specification, test rig requirements, and test specimens are currently being prepared.

A test specification for irradiation tests of the tie rod assembly in the GTR has been issued and the rig for performing the tests has been designed. The rig will be completed and checked out in July, 1963.

c. NRX-B Cooled Support Plate Tests

A full-scale plastic model of the plate was completed for stress and deflection tests. Plate configurations will be tested without flow tubes, with flow tubes, and with modifications involving cut-out areas in the lower plate.

13. Friction Tests

Test specimen and test rig procurement has been completed.

14. Study of Modes of Fracture and Deformation

Initial tests to check out the pressure vessel for testing specimens under a hydrostatic pressure and to calibrate the load cell have been completed.

15. Fatigue Properties of ATJ Graphite

The static flexural strength of ATJ Graphite perpendicular to the grain averaged 3300 psi.

E. NRX-B REACTOR MECHANICAL DESIGN

1. Core Cage Structure

A reactor design has been started which employs an internal metal core structure forming a continuous honeycomb extending from the core outlet end to the forward end of the shield section. The honeycomb structure traverses the entire section of the core and extends to the periphery. It provides a continuous shear web which, together with light flange structures at the forward and aft ends of the reactor, forms a structure with a depth equal to that of the combined reactor core and shield assembly.

The metal structure is cooled by the hydrogen propellant after leaving the reflector and before entering the core fuel elements. Axial control rods are supported in the structure and are cooled in the same manner as is the core structure.

This particular design is modular; that is, the honeycomb structure is fabricated from individual metal module tubes which are bolted together. The core fuel elements are clustered into groups by means of corrugated metal containers which accommodate the radial thermal growth of the clusters and fit into the module tubes. Pyrolytic graphite separates the corrugated metal containers from the fuel elements and minimizes the heat flux to the coolant.

The radiation shield is also a modular design. Each of the metal core structural module tubes accommodates a shield module in its forward end. The shield modules are simple assemblies of lithium hydride capsules. An assembly of springs is retained between the shield module and its associated cluster of elements and provides an axial force which locates the assemblies in position against axial g loads.

This design concept minimizes the use of graphite as structure and may have a high potential reliability. The development of such potential requires the solution of structural cooling problems, rather than the development of graphite as a structural material.

2. Graphite Modular Core Structure

The latest modular design employs a hexagonal graphite module tube which accommodates 19 full fuel elements. The gaps between the peripheral elements and the module are filled by strips of graphite. An existing 19-element transition block design has been modified to provide a hexagonal periphery, which is bonded to the module. A spherical seal is utilized at the outlet end where the block rests on the bottom support plate.

A metal cap at the inlet end of the module retains the elements, metering jets, and individual axial springs.

Six modules will be produced for mechanical testing, three from an extruded graphite material which has similar properties to ATJ graphite, and three from the newly developed cloth laminate graphite.

3. Graphite Support Plate Structure

A design employing individual elements pinned at the outlet end to a graphite support plate is nearing completion. The problem of cooling the thick peripheral sections in the graphite plate has been solved by using blind holes in those sections and bleeding flow from adjacent holes into the blind holes just below the plate inlet surface. The plate is set on a flexible, conical seat extending from the nozzle which provides an evenly distributed support pressure.

The graphite filler strips used to complete the core periphery are cooled by flowing coolant through a single channel in each strip which is more than 0.4-in. thick. This coolant is exhausted either through the blind holes, or through channels in the graphite between the bottom support plate and the nozzle support cone.

Stress analysis is essentially complete of the solid and segmented uncooled support plates under the core pressure drop load. The extreme edge reactions based on stress limits between 1000 psi tension and 5000 psi compression have been determined for the solid plate. The stresses in the segmented plate are not significantly higher than in the solid plate. A limited amount of opening of the joints under load is premitted. The maximum compressive stress in the segmented plate is 5395 psi. The maximum joint opening is approximately one third of the plate thickness for the above reactions.

The conical support seat is also being analyzed. The support cone must have sufficient flexibility to conform to the plate when it is distorted by thermal gradients and also to accommodate manufacturing tolerances at the interface while maintaining an acceptable support pressure distribution.

4. Forged Support Plate Plastic Model

The plastic model of the forged support plate has been received and inspected. Strain gage instrumenting of the plate is nearly complete. Adaptation of the low pressure plate test rig has been started.

5. Transition Blocks

Two of the prototype transition blocks (one made of ATJ graphite and the other ZTA) have been coated with niobium carbide. These blocks, in conjunction with a number of small samples coated by LASL, will be used to evaluate the problems associated with transition block sliding.

6. Lateral Support

Design effort has continued on two graphite ring lateral support systems.

The first concept employs internal and external segmented rings wedged together in series along the periphery of the core by a single assembly of axial springs at the inlet end. The applied load attenuates as it interacts between subsequent rings in the series. The attenuation can be minimized by using a large applied spring force at the inlet end and ring segments having small wedging angles.

A second arrangement imparts bundling pressure by using axial springs, located between parts of segmented rings, which apply a wedging action to mating segmented rings around the core periphery. This configuration utilizes an outlet end seal and provides uniform bundling pressure along the length of the core.

The lateral support test hardware design has been released.

7. Thermal Performance of Counterflow Cooled Tie Tubes

Tie-tube thermal analyses have been completed for 100% and 25% power cases for the core design employing two tie tubes per every 12-hex element spaces. A large portion (65%) of the hydrogen flow bypasses the tie tubes and flows directly into the core, while 35% of the flow makes two passes through the tie tubes before mixing with the remainder of the flow and entering the core.

THERMAL PERFORMANCE PARAMETERS

As-Calculated and reported in last Monthly Letter - 45% of Hyd. flow diverted through the tubes		100% Power 100% Hyd..Flow	25% Power 25% Hyd. Flow
	Hydrogen entrance conditions	200°R, 700 psi	200°R, 220 psi
62 psi	Pressure drop through tie tubes	65 psi	37 psi
565°R	Hydrogen temperature rise	507°R	1393°R
900°R	Maximum tie tube metal temperature	860°R	1570°R
627°R	Maximum temperature of load carrying tie tube	515°R	1120°R

It is apparent from the above data that a reactor incorporating this tie-tube cooling system can be operated at flow rates down to 25% of full flow without requiring reduction in reactor exit gas temperatures.

8. Sealing Studies of a Modular Core With a Cooled Support Plate

Studies have been initiated on the sealing of a modular core mounted on a cooled hot-end support plate. The design objective is to seal the module both at its seat on the support plate and at its cold-end attachment to the alignment plate; if the modules can be successfully sealed at both ends, then breakage of the modules or elements during operation cannot result in gross changes in the flow rates through the elements. Preliminary calculations indicate that the conceptual design has a very small leakage rate - approximately 0.03% of reactor flow. However, should a module box and one or more elements crack, the calculations indicate that the cold-end seals pass sufficient hydrogen to allow in-leakage into the module, and serious flow depression in the upper portions of cracked elements. Attempts to refine this seal design are continuing.

9. Flow Distribution and Pressure Drop in the Forged Support Plate

A digital computer program which solves for the flow distribution in the forged support plate has been completed. The first case examined with this program has been nominal orificing in each flow tube. Total pressure drop across the plate for this case was 40.6 psi, with a radial pressure gradient of 5.5 psi in both the upper and lower plenum chambers. The minimum mass velocity in any flow tube occurred in the center of the plate, and was 18% below average. Studies are continuing for a preferential opening of some of the flow tube orifices. It appears that the forged plate, when the hydraulic design is made optimum, will have a total pressure drop of between 25 and 30 psi, and that the minimum mass velocity in any flow tube will be within 10% of nominal.

10. Forged Support Plate Temperature Distribution

Analysis has continued on determination of those modifications of the forged support plate which are necessary for its survival in the accident case where the graphite and pyrographite liners have broken away from the gas flow tubes. The maximum metal temperature can be reduced from the melting temperature to below 2800°R by replacement of the regular A-286 tubes with nickel tubes with thinned corner sections. The design can thus be considered as marginal under such conditions. The use of a spray coated $Zr\ O_2$ inner liner for better protection in such cases is being considered.

11. Cooling of the Core Cage Structure

Preliminary steady-state calculations on the peak temperature distribution in a core with Y-shaped control rods housed in a metallic gridwork ("core cage") have been obtained. The coolant flows in three passes through the reactor: a first pass through scabbards housing the control rods, a second pass between the corrugated stainless steel which holds the fuel elements and the scabbards, and the third pass through the fuel elements. The peak temperatures were below 1100°R and 600°R for the corrugated stainless steel and the scabbards, respectively. Further studies will be made to determine optimum thickness of the pyrographite which insulates the corrugated stainless steel from the fuel elements.

12. Nuclear Design of a Reactor Incorporating a Core Cage

A cooled structure such as the core cage offers the possibility of using control rods within the core itself. An investigation was made of the possibility of incorporation of sufficient control rods to shut down the core in a flooded condition.

An estimate has been made of the amount of hafnium control material (0.2-in. thick) necessary to give a NERVA type core an effective multiplication factor of 0.95 when flooded with water. The material was in the form of "Y" shaped control rods housed in a metallic gridwork. To obtain a K_{eff} equal to 0.95 in the flooded case, the hex clusters (which are surrounded by rods) cannot exceed approximately 7-in. across the flats. This calculation was used to determine the number and size of control rods for the conceptual design. Seventy-two rods with a blade length of 1-3/4 in. are used: the use of rods of larger span might cut this number in half. Detailed four-group transport cell calculations have been initiated to verify the worth of these control rods.

Machine computations were made to determine the required fuel loading density for the core cage design. These calculations were made for three uniform fuel loading densities of 400, 450, and 500 mg/cc for an all stainless steel structure, and for a structure where the corrugated fuel support is stainless, and the scabbard is aluminum. The values of K_{eff} in an unpoisoned and unflooded core for the various conditions analyzed are listed below:

	Fuel Loading Density (mg/cc)		
Core Structural Volume Fractions	400	450	500
0.15 H_2 and 0.057 SS	1.006	1.030	1.0526
0.15 H_2 and 0.0176 SS	1.012	1.034	1.0533

These results indicate that for higher fuel loading densities the absorption of the stainless steel becomes less important i.e. the difference in K_{eff} for the two structures becomes smaller for the higher fuel loading

densities. They also indicate that the required fuel loading densities of a control rod design will be higher (approximately 500 mg/cc) than has been used in the Kiwi reactor.

The hydrogen worth for this core (excluding the reflector, upper plenum, and base plate hydrogen) was found to be $2.6, which gives a worth per kilogram of hydrogen comparable to that calculated for the NRX-A design.

This design incorporates large 61-element modules which introduces irregular variations in the thickness of the beryllium reflector. This irregular beryllium reflector was found to give large peripheral perturbations in power which will necessitate the use of a complex fuel zoning system.

13. Central Island Control Scheme

The worth obtained from a center-island control scheme utilizing control drums was analyzed for a NERVA type reactor. Beryllium islands of 2, 3, 4, and 5 in. radii were placed on the central axis of the reactor. In each case the outside core radius and fuel mixture was held constant. The effective multiplication factors for the various islands are listed below.

Be Island Radius (inches)	0	2	3	4	5
K_{eff}	1.082	1.091	1.098	1.102	1.099

A 0.05-in. thick poison region was placed around the 4-in. beryllium island, and the change in reactivity was noted. For a pure B-10 poison region the change in reactivity was $2.19; for a boral poison region the change noted was $18.6. Consideration of the reactivity loss associated with this poison in the drum-out position would reduce these worths; nevertheless, it is apparent that such a central island control scheme can amplify the present control margin appreciably. The fuel inventory requirements for such a reactor would be less than in NRX-A.

F. E-ENGINE REACTOR MECHANICAL DESIGN

There has been no activity on this project.

G. KIWI B6 SUPPORT

1. Phase 1 - Braze Development

Braze Development program as related to bottom plate design has been completed.

For joining the three different types of joints the following parameters have been determined and demonstrated: fit up of joint, selection of brazing alloy, configuration of braze material (foil or wire), furnace cycles, brazing temperatures and fixturing. A detailed report will be published following completion of fabricated test plates.

2. Phase II - Application of Developed Methods to Hardware

Suppliers have been selected and orders placed to furnish detail parts and for fabrication of two seven hole test plates.

Thermal conductivity test for each heat of raw material, an added requirement for the nickel castings, is being investigated.

Item 1.3.2 NUCLEAR SUBSYSTEM
THERMAL AND FLUID FLOW DESIGN

A. CORE COMPONENT ANALYSIS

Thermal analyses have been completed to establish the local temperature distribution about a tie-rod hanger within the top support plate. The TOSS computer program was used to evaluate both the axial and radial temperatures for the tie-rod hanger located in the center of the core. The maximum support plate temperature, which occurs at the bottom of the plate, was 409°R.

The stainless steel liner (which is placed inside of the pyrographite tubes of the tie-rod channel to contain any flaking of the pyrographite) has been redesigned with a formed spiral protrusion which will prevent the tie rod from coming in close contact with the wall. An analysis was performed to determine the pressure buildup behind the formed stainless steel liner tube resulting from the temperature increase of the entrapped air in the gap and in the helical depression between the liner and the pyrographite tube. When the entrapped gas temperature is raised to 941°R (the average operating temperature of the gap for the centrally located tie rod) the resulting pressure is 27 psia. At start-up the gas is cooled to 207°R, resulting in a pressure of 6 psia. Neither of these conditions appears to present a problem. In addition, the possible formation of explosive mixtures of air and hydrogen was investigated and found to not be a problem.

The tie-rod centering bushing, which also acts as an orifice for the tie rod flow, was selected during the last period based on component test results.

Two element placement and orificing documents were issued covering 621 elements for the Phase I Vibration core.

In analyzing the design of the lateral support system for thermal and fluid flow stability characteristics, it is necessary to determine the pressure and flow rate in the gaps between fuel elements in the core assembly. The analysis of the inter-element pressure distribution of the core using a 32 node flow model was completed, and the results were reported in WANL-TME-368. Both pressure and flow distributions were found for the conditions of 100% full power,

25% full power, 10 lb/sec flow with ambient hydrogen and no power, and 10 lb/sec flow with ambient nitrogen and no power.

In all cases the pressure and the flow to the core was found to be radially inward, which is believed to be a principal requirement for flow stability. For the 100% full-power case, the total inter-element flow was found to be 0.014 lb/sec. A more detailed flow model consisting of 390 nodes has been set up using the TOSS computer program which can be used to represent this problem. The initial results agree with the results from the 32-node problem. Additional modifications are being made to the 390-node model to include the effects of the filler strip expansion at the core periphery, the support-block clearance, element undercut at the exhaust end of the element, and inter-element gap radial distribution.

B. LATERAL SUPPORT AREA THERMAL DESIGN

Preliminary investigation on the effect of the gap between core peripheral filler blocks at power conditions showed the gap could not be neglected in the hydraulic model of the multi-seal lateral support system. Thus, modifications of the hydraulic code and hydraulic model, and the heat-conduction model on TOSS were made to include this radial filler block gap (nominally 2 to 7 mils). In addition, the conduction-model modifications included 60% of the filler-block-seal interface periphery as convective heat-transfer surface, such as will be the case with seals that are purposely slotted to provide the necessary design clearance. The remaining 40% is in conductive contact with the filler block. The pitch of the slots on the seal is such as to provide a point of radial support on every filler block.

Modifications of the programs have been completed. Calculations are being made of the thermal and fluid-flow characteristics of the seal configuration which uses leakage slots in the inner periphery of the seal segments machined to a depth to be hydraulically equivalent to the continuous circumferential gap of 0.008 inches. In addition, cases are being investigated to illustrate the effect of increasing and decreasing the seal slot depth from this nominal design case of 0.008 inches.

A parametric analysis was made to determine fuel-element temperature gradients due to fluid flowing from the peripheral filler block interface radially inward toward the center of the core. Based on the preliminary analysis of the leakage into the core, the radial inflow at the axial fuel-element hot spot is 0.00194 lb/sec in.^{2}. From the parametric study and based on this flow, a 0.005 inch gap between fuel elements, and coolant temperature of 1000°R entering the gap between fuel elements, there is obtained a maximum fuel element gradient of 400°R. The coolant reaches the fuel-element temperature approximately 0.030 inches radially inward.

A similar parametric analysis of the temperature gradient of the peripheral elements was performed for axial flow in a gap between peripheral filler blocks of 0.015 inches. This gap exposes the fuel element to axial cool hydrogen flow for the full length of the element and for the 15-mil width (15 mils is the maximum gap expected in the assembly). The results of this study, therefore, give solutions of thermal gradients for any bulk coolant temperature and any heat-transfer coefficient at the surface of the fuel element. Experiments are being prepared on this geometry using helium as a coolant. Attempts will be made to correlate the analysis and the experiments. The analyses to date show very localized gradients in the fuel elements.

C. COMPONENT TEST COORDINATION AND ANALYSIS

A report (WANL-TME-398) was issued on Design Significance of Component Tests. This report covers the design significance of test data acquired to date.

D. REFLECTOR AREA THERMAL DESIGN

Updating of the steady-state full-power operating characteristics of the core support ring and reflector support ring (dome end) were initiated. The former component was modeled on the THT conduction code. When the problem was run on THT, the code as received was found to be nonoperational. Coordinated effort with LASL was initiated to obtain an operational THT conduction code.

A recent change in nozzle heat-transfer characteristics has been recommended by AGC. This change increases the nozzle tube exit gas temperature

from 128°F to 162°F for liquid hydrogen feed at full power. Work is proceeding to include this change in the analysis and to determine its effect on reactor component design and performance.

E. THERMAL PERFORMANCE ANALYSIS

The gaseous and cold flow profiles proposed for the NRX-A1 test were calculated by the TNT (Thermal and Nuclear Transients) code. The cold flow profiles simulate powered run profiles for core exit gas temperature ramps of 15, 25, 50, and 100°F/sec. Generalized gaseous characteristics are determined, together with the method to predict the transient characteristics of any flow ramp. This information enables analyzed NRX-A1 test profiles in greater detail.

A re-oriented investigation of NRX-A2 emergency cool-down was initiated. This new effort will include the effect of the liquid volume stored in the cold gas mixer and feed line. The types of emergencies to be considered are loss of liquid coolant and scram, reactor scram without the loss of coolant, and fire. Preliminary calculations of the loss of coolant accident have been made for emergency cooling with gaseous hydrogen from partial power.

A transient code model of Kiwi B-4A was used to calculate the gas-flow rates that were used for the Kiwi B-4A cold-flow test. A report on the comparison of the code results with test data is near completion.

Efforts are continuing to modify the TNT code to a three-channel core model. This code will be used to demonstrate multichannel effects on laminar flow instability. A sample problem was been run but the results thus far have proved inconclusive.

Work necessary to include the aluminum replacement shield in the TNT code is continuing.

F. TRANSIENT FLOW ANALYSIS AND TEST

A series of experimental tests using the single-passage aluminum heated test section were completed this month. Other proof tests were carried out with liquid nitrogen in order that the system safety could be checked. The equipment performed satisfactorily; however, due to the low electrical resistance

of the metal test section at cryogenic temperatures, the desired levels of power dissipation could not be attained. A higher resistance test section is being fabricated.

An analytical solution using differential equations has been derived for transient two-phase heat transfer. The solutions can predict wall and fluid temperatures as a function of time and distance along a reflector channel. Predicted wall and stream temperatures are being compared with experimental values.

The report on the multiple passage tube investigation has been completed.

G. REACTOR COMPONENT FLOW AND CORROSION STUDIES
(Included under Item 1.3.5 in last month's report)

1. A-2 Single Element Corrosion and Flow Tests

The hydrogen corrosion furnace breakdown, as reported last month required re-welding and machining of the furnace body. After this work was completed, the body was hydrostatically tested and new internal parts installed. An insulating material was installed around the furnace electrodes to prevent the arcing which caused the damage. The heat exchanger was inspected during this period, cleaned with new gaskets, installed and re-assembled.

Since re-installation of the furnace, 14 corrosion tests (Nos. 43 thru 55) have been performed, including cold-flow check-out and calibration tests. Arcing at the upstream (cold end) chuck limited the duration of test until a new split chuck, mechanically clamped to the element, was designed and fabricated. This modified chuck maintains good contact pressure on the element and reduces contact resistance. Element expansion is provided by allowing the chuck to slide inside a graphite ring with test current being transferred from the graphite ring to the sliding chuck by a series of copper pigtails. Six tests (Nos. 51 thru 55) completed with this upstream chuck have shown no arcing. Test No. 51, performed at 4500°R, was run for 9-min 10 sec, and showed only two grams weight loss. Runs No. 52, 53 and 53B were each tested for five minutes at 4200 - 4500°R with a weight loss nearly double that which was experienced on Test No. 51. The axial thermal expansion of the test elements was estimated to

be 1/4 to 5/16 inch. The thermal expansion was determined by visually observing the movement of the element through the furnace viewport during testing.

Arcing is still present at the downstream (hot end) chuck, but is expected to be corrected by a new chuck design based on the experience gained with the upstream problem.

2. A-4 Support Block Flow Tests

The preliminary design of the furnace chucks for mounting the bottom support blocks in the high temperature testing furnace is complete. Detail drawings are in process.

3. A-8 Fuel Element Orifice Flow Tests

Production-type fuel-element orifices having nominal diameters of 50, 60, and 70 mils have been examined. Flow experiments were conducted and master orifices* for the cold-flow test were selected for each of these sizes. The pressure-loss coefficient was calculated for each of the sizes, and a curve of loss coefficient versus orifice diameter was plotted. From this curve, a dimensional tolerance was selected for the listed orifices.

The production orifice tester has been evaluated and modified to increase the sensitivity. This was accomplished by changing the size of the flow control (primary) orifice. It was determined that the maximum sensitivity is achieved when nominal diameters are the same for the primary orifice and the orifice being tested. The dimensional tolerances for the 50, 60, and 70 mil orifices were converted to readings for the production tester.

4. A-10 Fuel Cluster High Temperature Test

Layout drawings have been completed for the single-cluster corrosion furnace, which will be used to test a complete fuel cluster, including

*A master orifice is a physically and geometrically perfect orifice which will give true flow characteristics for that size.

the bottom support block, tie rod, and associated hardware. The layout drawings for the heat exchanger, which will cool the hot exit hydrogen gas from the furnace before filtering, have also been completed. Detail drawings of both units are being prepared. The layout drawings of the water system, used for cooling both the furnace and heat exchanger, have also been completed.

5. A-11 Flow Induced Vibration Test

Construction was started at the Waltz Mill Test Site to fabricate the hydrogen testing facilities. The current effort will include erection of the test cell, control room, process gas storage area, roads, and perimeter fencing. Specifications were released for bids for the piping system, including the high-pressure gaseous-hydrogen lines, low-pressure nitrogen lines, and the atmospheric vent system.

The test-rig pressure vessel was ordered, and the vendor design drawings and stress calculations have been reviewed. Procurement for the remainder of the non-deliverable internal test rig components has been completed. These items include the seven-cluster inner reflector, top support rings, support plate, and lateral support and seal system.

Procurement of the hydrogen-test-facility data-acquisition-system has been initiated. The system will have a capability of recording pressure, temperature, and vibration data on visual and tape recorders.

6. B-3 Lateral Support and Seal Tests

The lateral support and seal tests consist of a series of test models which are used to determine the individual component flow characteristics, pressure losses, and combined effects of the lateral support and seal system. These models include: the low-pressure single-seal plastic model, the high-pressure single-seal model, the high-pressure flat multiple-seal model, and the single-seal heated graphite model.

The single-seal low-pressure plastic model, which flows air past a single graphite support segment, has indicated that the leakage rate past the segment is a function of geometry and appears to be consistent with orifice pressure drop theories.

Equipment has been ordered for the single-seal high-pressure model, which will determine the high-pressure applicability of the low-pressure tests.

The design has been completed and the pressure vessel ordered for the flat multiple-seal test model. This model will permit an evaluation of the effect of many flow resistances in series and parallel.

The design was started for the single heated graphite test model. This model will study the effects of the influence of heated seals on leakage, of improved temperature gradients on leakage, and the effects of corrosion and erosion on heated seals.

7. C-1 Impedence Ring Tests

Air tests have been initiated on a model of the impedence rings for the inner reflector - outer reflector annulus. The flow rate through the model is varied, the corresponding pressure drops recorded, and therefrom pressure-loss coefficients are calculated.

A model of a larger section of the impedence ring for the inner reflector - outer reflector annulus is being constructed. This model is similar in construction to the model described above, but has a larger sector of the impedence ring.

Construction is continuing on the model to measure the loss coefficient for the impedence ring in the outer-reflector pressure vessel annulus.

8. D-2 Beryllium Reflector Assembly Flow Tests

Assembly of the flow loop for hydrogen experiments on the model of the beryllium reflector assemoly has been completed. The heat exchanger used to cool the hydrogen gas to liquid-nitrogen temperature has been received and installed. Installation of the instrumentation is continuing.

9. D-4 Flow Tests of Control Drum Shaft and Orifices

A draft of a memo describing preliminary experiments on a model of the control drum drive shaft has been completed. Fabrication has been completed on a new model which has a larger number of pressure pickups and total

pressure probes. Instrumentation on this model will provide a more accurate means of measuring the flow distribution within the model.

Procurement of the components for the scale model of the control drum, to determine the loss coefficients, is continuing.

Item 1.3.3 NUCLEAR SUBSYSTEM

A. REACTOR NUCLEAR DESIGN AND RADIATION ANALYSIS

1. Fuel Loading in NRX-A2

A review was made of the previous selection of design control-drum position used in fuel zoning, and the previous choice of 130° is being maintained. There will be temperature gradients at the core exit during operation, since reactivity will be shimmed to maintain the reactor operating drum angles always less than 130°. If the fuel loading should be designed for a drum a drum angle less than 130°, it would not be possible to assure that operation would always be less than the design drum angle and, consequently, overheating of the edge elements would result in addition to the generation of transverse temperature gradient (as in the previous case).

A preliminary loading scheme for the outer zones of the NRX-A2 core was derived using LASL measurement of fission distribution in the ZEPO B4 mockup experiments. A standard analytical method was then used to calculate the power distribution for the hot NRX-A2 core.

Based on application of the same analytical method to the ZEPO B4 mockup described in N-2-7686, correction factors were developed for the difference between theory and experiment, and these were then used to adjust the NRX-A2 calculation power distribution and loading. The final loading ranges in seven zones from the central loading of 417 mg/cc down to 136 mg/cc at the periphery. The new edge loadings are considerably reduced from the tentative zone loading described in WANL-TME-273; as a result, a reactivity loss of about $0.7 is incurred.

2. Negative Shim Analysis

Several negative shim distributions were examined for use in NRX-A. It was found that a homogeneous distribution of 50 fully shimmed unfueled elements over the central fuel loading region increases the radial fission density peak by 2.3%, reduces reactivity by $3.7, and slightly increases the control-drum

span. If the 50 shimmed elements are arranged in an annul s at the edge of the central zone, their worth is reduced to $3.1, but there is no increase in edge peaking or drum span.

The effective resonance integral used in this study for the NRX-A tantalum carbide shims were derived from the QUERY code, which implies a choice of either the "narrow resonance" (NR) or "narrow resonance, infinite mass absorber" (NRIA) approximations. These results were verified by check calculations using the ZUT code which performs the required integrations explicitly.

3. Methods Development

As a first step in the development of a completely programmed method for calculating channel-by-channel power factors, the existing PFC code was revised extensively and adapted to the revised NRX-A core periphery, which resulted from the lateral support redesign.

The use of two-dimensional calculations explicitly representing each fuel element is being investigated.

The method by which PAX measurements will be used to correct the calculated fission distribution is also under study.

4. NRX-A Experiments Performed in Kiwi-B4 ZEPO

A preliminary analysis of the NRX-A fuel substitution experiments, tantalum carbide shim experiments, and shipping poison wire experiments was completed. This preliminary analysis, based on the best estimates of material content of all the experimental equipment, indicates that the fuel element specifications, shim poison, and shipping poison wire specifications are adequate. More definitive analyses, utilizing the results of destructive chemical analysis of the components, are being undertaken.

B. SHIELDING AND RADIATION ANALYSIS

1. NRX Radiation Analysis

The 14-0 calculations of gamma heating for 90 points in the shield (flight type) and reflector regions have been converted into heating rates

separating prompt heating from decay-gamma heading. Conversion was also accomplished of the heating rates per gram fro steel to heating rates per gram of all other materials in the NRX.

Neutron and gamma radiation levels ten feet from the core center were computed for NRX with the aluminum mockup shield and with the LiH-SS shield.

Heating in the propellant tank has been recalculated for both the aluminum mockup shield and LiH-SS shield using the TIC-TOC-TOE code.

2. Methods Development

The Monte Carlo Program 18-0 was used to generate heating rates due to core gamma rays in the unshielded NRX-A assembly. R sults show that of the total gamma energy started in the reactor (16.67 mec per fission), 82% was absorbed in the core, 13.7% was absorbed in other components, and 4.3% escaped from the unshielded NRX-A assembly. Comparisons between Monte Carlo heating rates and those generated through use of the Point Kernel Programs 14-0 indicate that the Point Kernel results are higher at the core center by as much as 40%. Through use of the 18-0 code, heating rates were generated in the graphite reflector from gamma rays originated in the reflector from all sources. These gamma rays increase the heating by about 3% over the heating caused by core gamma rays. Heating rates in the Be reflector from gamma rays originated from neutron capture and inelastic scattering in the Be reflector increase the heating rate by 15% and 20% at the inner and outer radius of the reflector respectively.

C. REACTOR CRITICAL TESTS

1. Facility

Modifications to the building at the WANEF site, where the reactor critical experiments will be conducted, were completed. Installation and test of facility equipment was immediately initiated. The design modifications to the critical-test control-drum-drive scram and shock-absorber device (which previous testing had indicated was required) have been completed, and have been tested successfully to the design specifications. An entire drum drive mechanism prototype has been completed.

Special NRX experiments were completed at the LASL N-2 area on NRX-A2 fuel, poison wire, and shim reactivity.

2. Pre-Assembly Experiment, Proof Test Experiment

Design has been completed for these items to be used in the Pre-Assembly Experiment:

Shield locating template,
Shim extractor tool,
Fuel storage rack,
Poison-wire storage rack,
Work platform for overhead crane,
Support for floor under turning stand.

Design efforts are continuing on the core-support-plate handling fixture for the proof-test experiment.

D. REACTOR PHYSICS AND MATHEMATICS

1. Physics

Work on compilation of cross section data was continued

Work on the non-separable kinetics program continued. Several methods were defined by which the program could be altered to save computer time.

An analysis, using a digital computer program, was initiated of vibrations in the Kiwi-B^4 cold flow test. Measurements of the cinema film taken during the B^4 cold flow test have been made using a Vanguard analyzer.

Work has continued on a revision of the Conditional Monte Carlo program. A TNR report on the Conditional Monte Carlo program was prepared.

2. Mathematics

a. The LASL two-dimensional transport program DDK has been made operational. A series of comparison problems have been run.

b. A program to calculate the void area in the core due to the dimensions and the twist of the elements was begun this month, and

c. Work continues on a program which will record the complete history of all fuel elements.

Item 1.3.4 NUCLEAR SUBSYSTEMS REACTOR CONTROL SYSTEM

Reported under items 1.3.2, 1.5, and 2.4.

Item 1.3.5 FUEL ELEMENT FABRICATION AND DEVELOPMENT

A. FUEL ELEMENT FABRICATION

1. Raw Materials

Because of un-anticipated low yields and the inability to directly recycle in-house generated scrap, NUMEC will be unable to complete their order with the original gas allocation. Additional gas has been made available but there will be a delay in availability of beaded particles.

3M material presently being delivered on schedule and intended to be used for NRX-3 will be used to fill the gap created by the delay in NUMEC shipment.

Davidson Chemical has been given permission to convert gas to oxide but has not received approval to begin conversion of oxide to carbide. To date, their progress on the depleted order (which is serving as a qualification for their enriched order) has not been advanced enough to warrant proceeding with enriched material.

2. Process

Extrusion of fuel elements for NRX-A2 continued, with a total of approximately 1800 elements having been extruded to date. Initial data indicated that the original loading point of 446 mg/cc would produce elements on the low side of the fuel element tolerance range, and therefore the loading has been re-adjusted to 458 to raise the overall zone loading to a now-anticipated final level of approximately 414 mg/cc.

Leaching loss on the enriched elements has been quite consistent; the average loss is 6.1%. Coating loss has not been firmly established. Discrepancies have been found in the analytical procedures used for wet analyses. Prior results which showed that the coating loss was approximately 3-1/2% were in error, and these losses are believed to be more nearly in the 2 to 2-1/2% range.

Coating development of support blocks continued, but some difficulties were encountered in obtaining uniform coatings in both tiers of the coating fixture. Adjustments in temperature and flow appear to have

eliminated the problem, and final qualification progress runs are presently being initiated.

3. Inspection

The eddy current system is operational; both electronic portions and automatic fixturing have been completely checked out. A second eddy current system has been ordered and design has started on a third system of the type currently used by the Argonne National Laboratory.

Gamma counting equipment continues to perform satisfactorily, and the attenuation curves required to compensate for the presence of carbide lining have been developed. Problems of erratic readings and drift with beta back-scatter equipment appear to have been defined; the trouble lying largely in the coupling between the light pipe end and the photo-multiplier tube. New "Strontium 90" microsphere sources have been ordered to facilitate the construction of additional probes for the back scatter equipment.

4. Equipment

The second small dual furnace has been activated and will be used for development of coating techniques on cups and finally as a supplement to the first furnace for block coating. The new vapor deposition furnace is being installed.

B. FUEL ELEMENT PROCESS DEVELOPMENT AND CONTROL

Work has been initiated on a series of experiments designed to increase the efficiency of our mixing operations by reducing the viscosity of the Varcum 8251 binder. The reduction in viscosity is intended to result in more uniform distribution of binder during mixing. Variations in viscosity will be accomplished through additions of dioxane to monomer free furfuryl alochol.

It has been noted that density measurements made on "as-graphitized" elements are not in agreement with similar measurements made on the same elements in the "as-machined" condition. Some typical measurements indicate $\sim$ 0.001 gm/cc higher density as machined from end samples, and $\sim$ 0.02 gm/cc higher for end-middle-end samples.

The cause of this difference has been attributed to three possible causes:

1. Temperature gradients in graphitizing which would cause the sensing of lower temperatures at the extreme ends of fuel elements, thus resulting in lower densities.

2. Density samples taken from the ends contain "disturbed" material; a reflection of the manner in which the extrusion was cut to length.

3. The formulation of fuel-poor skins on the hex flats and around the holes.

The machining operations remove these skins, presenting material of higher fuel content in an as-machined density sample, thus resulting in higher composite densities.

The first two items listed above account for end-to-middle differences while it is believed that the last item may be the basis of the difference between the as-machined and as-graphitized densities. To make certain that densities are being taken on the sample most representative of the finished element, corrective action has been initiated to sample for densities in the as-machined condition.

Eighty-six unfueled elements were extruded using new extrusion die pins in an attempt to extrude coolant holes to size. Twelve of these were extruded with the intention of sizing both the holes and the outside hex. A sample of 34 elements representing 1292 hole diameter measurements shows a distribution of $\pm$.0006 in. about .0978 mean. With present tolerance allowance of .098 $\pm$.0005, the rejection rate would be 11%.

A sample of twelve elements measured as-graphitized across flats indicated that, for 117 measurements, the dimensions varied between 0.7551 and 0.7668, or a spread of 0.0017 inch.

Eight additional experimental batches are currently in the line with no data available at this time.

An effort has been made to eliminate the "hook" which exists within the first two inches of the un-numbered end of the fuel element. This hook is a result of the elements standing in a vertical position during bake. An unfueled element was suspended from the top of the bake fixture, with the bottom end hanging free. After baking, this element was compared to a similar element baked according to current procedure. This test indicated that "free suspension" will probably produce an element free from the hook currently experienced. This experiment will be duplicated on fueled material.

C. EVALUATION AND DEVELOPMENT OF REACTOR FUEL MATERIAL

1. Physical Properties

a. Thermal Expansion

A thermal expansion program was initiated to determine the effect of graphite shrinkage on conventional thermal expansion measurements. The revised program may be summarized in this manner:

(1) Conventional dilatometer measurements made in helium in both transverse and longitudinal directions were continued on both fueled and unfueled graphite. Attempts were made to account for shrinkage effects. Shrinkage as a function of time and temperature is being studied.

(2) A brief study of thermal expansion was made in the Hydrogen Corrosion Facility. This study was initiated due to concern that the thermal expansion of the reference fuel might be higher than predicted by the conventional measurement. Measurements made by telescopic observations of marker movements indicated that the anomalous thermal expansion effects were related to spurious effects in the Test Facility, and not to the graphite fuel elements.

(3) The effect of rapid heating on apparent thermal expansion was studied by means of resistance heating samples in a device equipped with a dial gauge to measure sample movement. Although the device could not be used to develop accurate thermal expansion measurements, due to the presence of thermal gradients, it proved useful in studying the relative effects of heating rate on the apparent thermal expansion. Initial longitudinal

thermal expansion measurements made with this device indicate that the expansion data are essentially independent at heating rates up to 1900°C. Above this temperature, shrinkage due to further graphitization makes the heating rate significant.

b. Mechanical Properties

The fatigue testing phase of the program to study the feasibility of proof testing fuel-length elements by flexure testing was essentially completed. A final evaluation of the program test results is now in progress.

The first set of Vib. 1 elements from Oak Ridge (Y-12) have been tested in flexure. The results are tabulated below.

FLEXURE STRENGTH OF VIB. 1 ELEMENTS

Type of Element	No. of Elements Tested	No. of Samples	Ave Stress at Outer Fiber (psi)	1 σ (psi)	Range (psi)
1-hole	2	12	4916	390	4000-5380
19-hole	32	96	5090	570	3840 6190
19-hole (polished)	1	6	5040	300	451[illegible]-5370

Three standard 6-1/2 inch long specimens were taken from each element, one from each end and one from the center. These specimens were then broken at room temperature on the standard rig using four-point loading with a six-inch outer span and a two inch inner span. Exceptions to the sampling procedure described were the 1-hole elements and the specially polished element, which were sectioned into six equally spaced specimens. The average strength, standard deviation, and range of all the elements tested do not differ appreciably from the data reported previously on bead-loaded fuel elements.

It was noted that several specimens which were tested with the engraved (numbered) face in tension broke at lower loads (~ 20%). It also seemed apparent that in such cases fractures tended to follow figures with long perpendicular paths to the extrusion direction, i.e., the numbers 1, 0, and 4.

As a further check of surface preparation or condition effects on strength, a rod was sectioned and the samples metallographically polished on the flats before testing. The test of this element done similarily to the as-received elements, indicated that minor machining defects or surface flaws do not affect flexure strength in the same degree as do the more prominant defects produced by engraving.

c. X-Ray Studies

Determinations of NbC liner stoichiometry by lattice constant measurements were continued. Type 4 coating on element 5-31-37 showed a gradual decrease in C/Nb ratio from the cold end to the hot end. The lowest observed ratio was 0.94, which is well above the requirement that the C/Nb ratio be at least 0.90.

d. Hydrogen Corrosion Studies

The test results of three successful tests during this period are presented below. These data are in good agreement with similar data reported previously.

SUCCESSFUL HYDROGEN CORROSION TESTS

(H_2 flow = 500 scfm, He flow = 42 scfm)

Element No.	Power (kw)	T max (°F)	Time (min) To T max	Time (min) At T max	Weight Loss (grams)
2793	630	4050	1.5	9.2	2.0
2806	577	3800	1.2	5	4.5
4054*	650	3540	1.7	5	not meas.
4054**	605	3520	1.7	5	10.0***

*First Test
**Second Test - arcing failure occurred in hot end chuck
***Combined weight loss first and second tests.

e. Reactor Shutdown Corrosion Studies

The reaction of NbC powder (325F) which was treated with dry nitrogen at 700°C for 48 hours with a flow rate of 1 liter/minute showed a weight gain of 3.2 per cent per gram of material. This gain in weight is about the same as obtained previously at 550°F. NbC coating obtained from the channels of a fuel element was treated with nitrogen. The results were inconclusive because it appeared that some of the graphite of the element adhered to the NbC, thus masking the results.

f. Hydrolysis Studies

The effect of thermal heat treatment at temperatures of 1800°, 2200°, 2400°, and 2600°C for 1/2 hour upon the subsequent hydrolysis of coated fuel particles held at 100°F and 100% relative humidity, is under investigation.

Preliminary results have been obtained for pyrocarbon coated UC_2 particles from 3M and NUMEC sources. The results correlate well with metallographic and microradiographic observations made previously for the same particles and heat treatments.

g. High Temperature Behavior of Fuel Elements

The quantitative and semi-quantitative evidence of uranium migration obtained from kinetic studies using alpha-counting and metallography have been interpreted in terms of a tentative theoretical model. A report of recent studies of the effect of various heat treatments on uranium migration in fuel particles and fueled graphite is being prepared. Experiments are in progress to test the validity of the proposed migration mechanisms.

h. Leaching

The leaching apparatus is in operation. Three runs were made to check out the furnace, the HCl system, and the trapping system for UCl_4 and excess HCl and Cl_2. All systems performed satisfactorily. Radioactivity was checked on all products found in the trapping system. The apparatus can treat three six-inch sections of an element at one time.

j. Coating Development

(1) Fuel Particle Coating

Preliminary tests are being made in glass apparatus to determine design data needed to construct two high-temperature fluidized bed systems for coating fuel particles. It is planned to coat these particles in batches of 50-100 grams per run with either pyrolytic carbon or refractory metal carbides. Raw materials are on hand for producing the desired types of coatings. A sufficient quantity of uncoated UC_2 fuel particles for extended experimental studies has been ordered. This fuel will conform to present NERVA specifications for uncoated particles containing natural or depleted uranium.

(2) Fuel Element Coating

Background information is being obtained to permit design and construction of a chemical vapor deposition system for coating sections of fuel elements internally and externally. It is planned to concentrate on NbC deposition for the initial studies. A workable unit already exists for coating the surfaces of fuel-element sections with pyrolytic carbon. Parametric studies will be conducted to determine optimum conditions for the coating of internal element surfaces or other geometric shapes.

k. Fuel-Element Thermal Stress Experiments

A system has been designed, and is under construction, in which fuel-element sections will be subjected to radial thermal stress experiments. This work is to be conducted to determine the effect of cold hydrogen leakage on peripheral element surfaces exposed to this gas during reactor operation. There is some concern that the thermal gradient introduced between center and surface of the element may initiate fracture in the element. The purpose of the experiments will be to determine whether such fracture can be initiated and if so, to determine the beneficial effect which might result from depositing a pyrocarbon coating on the exposed surface.

l. Thermal Stress Experiments in TREAT

Three preliminary transients were run in autoclave CEN-148 at Argonne National Laboratory. Radial temperatures were compared between the center channel and an apex channel of a 1-1/2 in. long hexagonal fuel sample.

The "flat-top" steady-power transient resulted in a maximum radial temperature difference of 20-50°C, as compared with the 250°C previously calculated, which assumed no heat loss except by radiation from the surface. Apparently a major portion of the heat generated was lost by helium convection in the fuel-element coolant channels rather than by radiation from the fuel surface. The 490-Mw-sec transient produced a radial temperature difference of 180°C. A maximum gradient of 350°C was predicted by a theoretical model in which the assumption was made that there was adiabatic heating to the same maximum temperature as that of the transient, followed by radiative surface cooling of a long equivalent cylinder. The difference can be accounted for by the fact that appreciable heat loss occurred from the two sample ends. Transient temperature traces indicate that initial fuel heating is essentially adiabatic, and that well defined temperature gradients (and thus stress levels) are best obtained by short period pulses.

The sample from CEN-148 was intact and appeared to be relatively unaffected by the testing. The NbC lining did not show signs of having melted and there was very little evidence of carbon vaporization. The sample weight loss was 0.04% and there was essentially no change in sample dimensions. The W-Re thermocouples were undamaged.

m. GETR Fuel Material Irradiation Experiments

The Document WANL-TME-375 Insertion Request Data and Hazards Analysis for the High Temperature Fuel Irradiation Behavior Experiments, Capsule Series WANL-TT, has been prepared and distributed.

n. High Temperature In-pile Loop

A preliminary feasibility study of a high temperature in-pile test loop for evaluating NERVA fuel material was completed. The following parameters were used as a basis for the design:

(1) Fuel - 3-ft long hexagonal element.
Maximum power density - 4 kw/cm^3.
Total heat generation - 400 kw.

(2) Temperature - 4000^{o}F (Maximum in matrix).

(3) Pressure - 685 psia (inlet)

(4) Irradiation time - up to 30 minutes.

(5) Neutron flux - 6 x 10^{14} nv (unperturbed).

(6) Coolant - Helium
(helium doped with hydrogen is also under consideration).

The preliminary study demonstrated the initial feasibility of the high temperature dynamic loop and revealed the need for further consideration of the in-pile tube, high temperature material problems, and heat exchanger design.

Item 1.3.6 DEVELOPMENT, FABRICATION, PROCUREMENT, MANUFACTURING

A. DEVELOPMENT PARTS, FABRICATION AND PROCUREMENT

1. General

Procurement effort continued for all reactor assemblies and for component testing. Potential schedule slippages increased during the month as noted due to fabrication difficulties.

2. Shield

A simulated shield machining order was placed for NRX-A1, A2 and A3. NRX-A3 procurement releases were issued for the flow screen, seal ring, seal flange, and related miscellaneous hardware. The NRX-A1 simulated shield forging was shipped.

3. Outer Reflector

The dome end support rings were shipped for the outer reflectors of NRX-A1 and A2. Simulated outer reflector sectors for initial vibration core testing of the Phase I Vibration reactor were shipped.

4. Inner Reflector

Lateral support seal segments of the inner reflector were completed for NRX-A1, A2, A3, and component tests, but are held for plunger design modification. The dome end seal delivery is delayed by vendor development of fabrication procedure.

5. Core

Unloaded core element delivery for Phase I vibration core and associated component testing was accomplished, including replacement by vendor of rejected elements.

Modifications of NRX-A1 core elements to insure a pressure relief plenum at the hot end and for acceptance of instrumentation were described to the vendor following design release. Modification machining was initiated.

A partial shipment of NRX-A1 elements was made.

The NRX-A1 interface seal assembly order was placed.

Delivery of prime cluster plate material for NRX-A2 and A3 was delayed due to vendor inability to produce to requirements. An order was placed for the alternate material for NRX-A2.

Blank orifice jets were delivered. Partial delivery of orifice jets for NRX-A1 received.

Insulating cups and washers, NRX-A1, A2 and component tests were received.

B. MANUFACTURING ENGINEERING AND SERVICES

1. Poison Rods

Vibratory compact filling of stainless steel tubing with boron carbide, drawing of filled tubing to size, and straightening of proper length rods, is complete for initial requirements. It was necessary to develop a brazing technique which would insure retention of boron carbide. Development of the protective polyethylene coating is continuing. The use of shrink tubing appears to be the preferred method. Procurement of proper size tubing is being followed.

2. Tie Rods

Examination of sample rods established the need for close control of grain size in X-750 raw material, and the process specification has been revised. Solution treating and aging shrinkages have been [illegible]ned and integrated into manufacturing dimensions. The supplier has proces[illegible]d 25 specification-grade full-length tie rods that are now in heat treat.

3. Orifices

Partial shipment of each of 12 different size orifices have been received, totaling approximately 33,000 pieces. Selection of master orifices and tolerance bands is continuing, and three sizes (.050 - .060 - .070) have been selected.

[redacted]

4. Fabrication of 2219 Al Material for Application on Core Barrel and Dome End Seal

A method of resolution heat treating to T-42 has been developed for both core barrel and dome end seal, including both the fusion and resistance welds. Resistance welding procedures have been developed for both the barrel and the seal. Hydraulic resizing of both seal and barrel is under development, and dimensional changes during aging are being investigated.

5. Fabrication of Nickel Alloys for Application on Nozzle End Seal and Spring

Correction factors and fabrication methods are being developed to compensate for dimensional changes of Inconel 718 during aging and TIG welding techniques which have been determined for the Inconel 718 nozzle seal and Inconel-X seal spring.

6. Fabrication of Flow Screen

A sintered screen was selected to facilitate spinning the screen into a dome without altering the mesh pattern. A method of sintering the required 39-in.-wide screen was developed by wrapping the screen on an Inconel mandrel as a sandwich, with a slave sheet painted with "Stop-Off". The continuous furnace is cycled by adjusting the conveyer speed so that the attached thermocouple readings match the standard sintering cycle. All other items of process development, such as spinning and brazing, are complete.

7. Control Drum - 6061T-6 Aluminum

Electron beam welding techniques are being developed for the tubes-to-end cap weld. Tentatively, a need for both filler wire and weld "prep" has been demonstrated.

Magnetic forming techniques for mechanical joining of the tube to the cap joint is under investigation, and samples are being prepared.

C. REACTOR ASSEMBLY, PACKAGING AND SHIPPING

The necessary assembly stands, fixtures and tooling are available, and the Reactor Assembly Laboratory has commenced operations. Reactor-assembly process outlines for the Phase I vibration reactor have been written. Orificing of elements for this reactor is nearly complete. The process outlines for the NRX-A1 and NRX-A2 reactors are being set in final form.

Criticality procedures for the Reactor Assembly Area are being established. These procedures will be used during the assembly of the NRX-A1 reactor as a final check prior to use during the assembly of the NRX-A2 reactor.

The necessary efforts were completed for the scheduled test run by railroad to NRDS of a reactor shipping container with a dummy load. The railroad cars, the container (inner and outer), and the dummy load, were instrumented.

Item 1.3.7 NUCLEAR SUBASSEMBLY
DEVELOPMENT TEST PLANNING AND OPERATION

There was no activity on this project.

Item 1.3.8 DEVELOPMENT TEST PLANNING AND ANALYSIS

A. GENERAL

Preparation of the NRX-A2 Test Plan and the NRX-A1 Test Specification is continuing.

Revision 1 of the NRX-A1 Test Specification was submitted for preliminary review.

WANL-TME-401, NRX-A1 Specifications for a Cinematographic System, TV System, and Illuminating System, was completed.

The preliminary start-up of the mixing chamber at the Nevada Site was witnessed. Tentative run profiles for NRX-A1 were reviewed with site personnel.

B. NRDS, TEST OPERATIONS

On-the-job training of both technicians and engineering personnel has continued, and Test Cell A indoctrination courses were initiated.

The mixing chamber installation at the new reactor purge line, and the actuator installation for ACV-3 were completed.

The design for Test Cell A shed modification was completed, and work continued on the design of Test Cell A nuclear instrumentation system modification, and preparation of a proposal for modification of the Control Point console.

C. NUCLEAR SUBSYSTEM ASSEMBLY, DISASSEMBLY, AND POST OPERATIVE OPERATIONS AT NRDS AND LASL

A preliminary ROVER/NRDS R-MAD schedule was prepared.

The post-operational examination section of the operation support plan was submitted.

Review of Test Car Assembly Manual is in progress.

On-the-job training of both technicians and engineers continued.

Item 1.3.9 REACTOR MODELS AND MOCKUPS

The completed NRX-A instrumentation mockup of the previous (November, 1962) design was disassembled. This mockup contained pressure and temperature instrumentation only. Photographs were made during disassembly to show details of instrumentation.

The following mockups and models have been completed:

1. Instrumentation stalk seal assembly for design and test evaluation.

2. Instrumentation stalk assembly braze plugs for pressure testing of seal assembly.

3. Control-drum poison plate and spacers of advanced concept for fabrication test study.

4. Instrumentation and pressure probe hold-down straps for instrumentation mockup.

5. Locking devices for design and test evaluation.

6. Support blocks for coating development and test evaluation.

7. Seal segments for reactor mockups and design evaluation.

8. Mockup of core support plate, core support ring, and dome-end outer-reflector support ring for development of instrumentationlayout for NRX-A1.

9. A model of a regular cluster plus a number of full-scale regular clusters were assembled to assist in determining the feasibility of eliminating the alignment sleeves in the cluster assembly.

10. Mockup of a section of the lateral support block assembly used for testing and design evaluation.

The following models or mockups are in process:

1. Irregular fuel cluster assemblies for core periphery assembly and design evaluation.

2. Core filler strips for design evaluation and assembly checkout mockup.

3. Detailed model of outer reflector support rings, sector, and control drum model to be 12 inches long and fabricated of plexiglass and aluminum for design evaluation and presentation.

4. Simulated support retainers for design evaluation and installation on instrumentation mockup.

5. Instrumented support retainers for design evaluation and installation on NRX-A1 mockup.

6. Non-fueled graphite elements for assembly checkout mockup.

7. Reactor components for NRX-A1 assembly checkout mockup.

8. Inner reflector and core support plate for instrumentation mockup.

9. Prototype tools and devices for bundling of the core, assembly of seal segments, filler strips and lateral support springs.

Item 1.4 THRUST CHAMBER ASSEMBLY (TCA)

A. THRUST CHAMBER ASSEMBLY

The most important problem currently experienced in this subtask concerns the quality of the nozzle aluminum jacket; that is, the lack of adequate tensile strength and elongation properties following heat treatment of the cast jacket. During this report period, a presentation on this subject was made by Aerojet to SNPO-W and SNPO-C personnel at Washington. Subsequent to this meeting, a NERVA nozzle task force was formed in order to expedite resolution of these fabrication problems, and to obtain satisfactory nozzles for the NRX-A and thrust chamber assembly component development test programs. This task force will devote full-time effort to achieve solution of all nozzle fabrication problems.

A feasibility study for cryogenic seal testing in support of the NRX-A program was initiated.

A rubber water bag and wooden collar to take up the pressure vessel internal volume during helium leakage tests at ambient temperature of the metallic seal was designed and released for fabrication. The specification for these tests has been written.

The first set of pressure-vessel metallic seals was inspected at Marquardt, Van Nuys, California. These seals must then be lead plated prior to completion of fabrication.

The preliminary design of the low frequency drive unit and the final design of the pressure-vessel tooling and air bag were completed for the TCA dynamic test. Dynamic analyses in support of the TCA dynamic test program were continued. Materials for the mass core simulator for the TCA dynamic test were received and fabrication was initiated.

B. NOZZLES AND EXTENSIONS

1. Heated-Bleed Nozzles

a. NERVA Nozzle S/N 001N

This nozzle is at Howard Foundry for casting, and will be cast after patterns are completed.

b. Reactor Back-Up Nozzles SN/001L and S/N 002L

Reactor back-up nozzle S/N 001L is ready for casting.

Due to the known low ductility of the aluminum jacket on reactor back-up nozzle S/N 002L, the nozzle was prepared for firing by wrapping it with high-strength glass tape, bonded with an epoxy resin. The glass wrapping was intended to restrain the cast aluminum jacket of the nozzle against failures induced by thermal stresses. The wrapping was applied directly to the as-cast surface of the nozzle, and was oriented along planes normal to the nozzle axis. The manifold at the nozzle exit and the nozzle-pressure vessel flange were not wrapped because of the difficulty in retaining the glass tape in these narrow areas. The wrapping varied in thickness from about one inch at the nozzle-pressure vessel flange, to about four inches at the throat.

The four-inch thickness at the throat was caused by initiation of build-up at this point, tapering back to the flange area, and was not primarily a stress requirement.

One LO_2/LH_2 simulation hot firing of the glass-wrapped reactor backup nozzle was then conducted. Injector S/N 1482, having cooled baffles and copper face plates, was used for this test. This injector was also used in the Kiwi-B S/N 001lK nozzle test. The objectives of the test were to obtain nozzle tube bundle heat-transfer data and to evaluate the glass wrapping restraint.

Total firing duration was slightly less than 8 seconds, as predicted, and the test was completed with no apparent incident. However, inspection of the nozzle after the test revealed that the nozzle - pressure vessle flange was cracked between bolt holes along the bolt-circle diameter for about 90° of arc. The test records showed that a perturbation occurred in the traces of accelerometer, valve, and pressure at about 0.47 seconds before shut-down fire switch. This was further substantiated by movie film records showing a puff of vapor from the flange area at about the same time. It is believed that these events signify the cracking of the flange. The nozzle was apparently not damaged otherwise. A complete X-ray survey will be made, and the nozzle will be dimensionally inspected.

The injector, S/N 1482, was found to have eroded in the outer channels following the test. It is believed that this erosion was caused by insufficient cooling at the low flow rates and velocities in the oxidizer channels. Therefore, other injector patterns will be evaluated to produce higher velocities in the cooling channels and through the injection orifices.

2. NRX-A Nozzles

Due to the requirement for camera and light ports in the NRX-A1 (cold flow) nozzle, S/N 0000010 hot-bleed nozzle was diverted to the NRX-A reactor nozzle program. Three holes for two lights and movie/TV cameras (in one port) were cut into the tube bundle. The manifolds, which provide coolant flow around the ports, were welded to the tube bundle. The tubes were swaged to obtain the proper joint clearance and the nozzle was brazed.

A Kintel 2001-11, "C" lens mount, television camera was selected to meet the size and quality of picture requirements. The Milliken DBM 5A, 200-400 fps movie camera was selected on the bais of film positioning, loading capability, and physical dimensions. Color-Tran, LEX-38, lamp housings were selected.

The cast aluminum jacket on NRX-A nozzle S/N 0000004 was X-ray inspected and prepared for heat treat.

Nozzle S/N 0000005 is ready for casting the jacket.

The wire interlocks were brazed to nozzle S/N 0000006.

During this report period it was found that there was inadequate weld penetration in the joint between the nozzle coolant tube and the cast tube adapter. Tubes for five nozzles at LRP plant of Aerojet, S/N 0000004, 0000005, 0000006, 0000007, 0000010, and tubes yet to be delivered from the vendor, may also have inadequate weld penetration in this joint. This can only be determined by sectioning each tube assembly. Investigation of causes of the problem was initiated. Pending the outcome of this investigation, the tubes at the vendor's plant will be repaired by cutting the adapters off and welding new adapters on the tubes. Three of the above five nozzles at Aerojet LRP (S/N

0000004, 0000005, 0000006) are brazed and have been proof tested to 1040 psig. These tubes are being reinforced by TIG brazing. The other two nozzles (S/N 0000007 and 0000010) are not brazed, and will be weld repaired.

3. Hot-Bleed Nozzles

Assembly and detail drawings of the nozzle and hot-bleed port have been completed. Analyses continued in determination of chamber pressure, flow rates, and mixture ratio for simulation of the port at reactor conditions. The final report is being prepared for the six hot-bleed port firings conducted earlier in this contract year which utilized the Titan modified XLR87 hardware. The first hot bleed nozzle, S/N 000001C, was delivered to the NRX-A program to be used as the cold-flow (camera and light port) nozzle, see Discussion above, paragraph B-2.

4. Adapters

a. Test Stand-Nozzle Water Cooled Adapters

All parts for the skirt diffuser are on order; tooling has been ordered and will arive on schedule. Drawings on the skirt-diffuser adapter were released on all final assembly components. Dynamic and stress analyses, a flange heating study, and a hydraulic analysis were continued.

b. Nozzle-Injector Adapters

Adapter S/N 001K was completed and assembled with the S/N 002L nozzle test assembly.

Adapter S/N 001N was completed. However, leaks were discovered during the proof and leak tests between the aluminum jacket and the adapter to injector flange. The leaks will be repaired.

The tube and chamber of adapter S/N 002K were proof and leak tested to determine if any leakage around the aluminum jacket occurred as in adapter S/N 001N. No leakage was found.

Adapter S/N 002N is ready for installation of the overboard dump torus.

Adapter S/N 003N has completed the first braze cycle and is presently waiting for rework of hydro tooling for proof and leak testing of the tube bundle.

5. Injectors S/N 0241, 0242, 0260

Injector S/N 0241 with steel face plates is 90% completed. This injector was converted to have copper face plates and was ready for drilling of the orifice pattern. Installation of all weldable components for injectors S/N 0242 and 0260 have been initiated; these injectors are 70% completed.

Drawings were made to convert the steel face injector S/N 241 to copper face plates and copper baffles. These drawings convert the injector to the general configuration of injector S/N 1482, which was used on the Kiwi B S/N 001K and on the reactor back-up nozzle S/N 002L tests.

Injector S/N 0112 (which had been modified to incorporate an orifice pattern having a uniform mixture ratio distribution across the face of the injector) was tested. This injector employed stainless-steel face plates with like-on-like double rows of impinging orifice pairs for both the fuel and oxidizer pattern. Post-fire inspection revealed severe injector face plate erosion in the outermost channels. Since this is the second time stainless steel face plates have eroded, the injector development program has been re-opened for additional testing.

6. Extension

The heat-transfer report on the nozzle skirt is 80% complete. The final design report has been delayed due to the redesign of part of the skirt assembly, i.e., the initial reinforcing rings were shown to be inadequate and have since been redesigned with a larger cross-sectional area.

B. THRUST STRUCTURE AND GIMBAL

Redesign was initiated of the lower thrust structure assembly S/N 0000001 for use in the initial phases of the TPA test; fabrication is complete, and the unit is being prepared for static structural testing.

Lower thrust structure drawings were reviewed for producibility and the drawings are being changed accordingly.

[illegible]out was completed of the electrical connector mounting flange for upper thrust structure S/N 0000008 to be used in the CFDTS.

Due to a design change on the gimbal support housing from a welded piece to one machined from a single block of metal, fabrication completion dates must be revised for the thrust structures using the improved gimbal support housings

Fabrication continued of the dummy gimbal actuators for the thrust structure resonance survey and the TCA dynamic test, and of the fairings for the gimbal support housings to be used in the TPA test, TCA dynamic test, and CFDTS assembly.

Dynamic analyses are continuing, and all tooling and instrumentation has been completed for the resonance survey of thrust structure assembly S/N 0000001. The reaction mass baseplate has been installed, and the instrumentation assembly has been checked out and calibrated.

The test specification has been issued for the static structural test of the lower thrust structure S/N 0000001 and has been completed for a similar test of the upper thrust structure. Dimensional (as-built) measurements were made of both the upper and lower thrust structures in preparation for the static structural tests Designing of the final items of test tooling for the thrust structure static tests was completed, and the design was released for fabrication.

Fabrication of the following thrust-structure test tooling items was completed:

Test Fixture	Gimbal Loading Fixtures
Gimbal Simulator	Gimbal Actuator Support Loading Fixtures
Pressure Vessel Closure Simulator	Clamp, Pressure Vessel Closure to Lower Thrust Structure

Stress analysis of the RIFT joint was completed. All analyses of the thrust structure and gimbal have been revised to reflect current design

criteria and structural loads. Predicted strains, rotations, and deflections for the lower thrust structure tests were made.

D. PRESSURE VESSEL

NRX-A2 pressure vessel, S/N 0000002, was satisfactorily hydrotested.

Analysis of preliminary data from this test was initiated. Preliminary evaluation indicates that the test was successful in satisfying its three primary objectives of

> Demonstrating the ability of the pressure vessel to withstand room temperature proof pressure
>
> Providing information on flange deflections and rotations and stresses in areas computed to have minimum margins of safety
>
> Demonstrating the ability of the structural nozzle diameter, S/N 0000015, to withstand a proof pressure.

The pressure vessel was tentatively accepted by the Material Review Board. However, final acceptance is withheld pending successful repair by the vendor of through wall leaks in two closure instrumentation ports as indicated by the liquid penetrant inspection.

The test specification for the hydrostatic pressure test of the titanium NERVA pressure vessel, S/N 001T, was published. All tooling required for the hydrostatic pressure test of S/N 001T was completed.

Tooling required for applying an axial tension load of 81,500 lb to the S/N 001T pressure vessel was designed, and drawings were sent out for fabrication cost estimates. The S/N 001T pressure vessel was instrumented in preparation for the hydrostatic pressure test.

Fabrication of criticality pressure vessel S/N 0000001 was completed and is ready for shipment.

Fabrication of pressure vessels S/N 0000003 and S/N 0000004 is in process. Closures for both assemblies are being machined, and girth weld No. 1 on the cylinder of S/N 0000003 has been completed. The cylinder for S/N 0000002 is awaiting machining of additional instrumentation holes for temperature and pressure taps.

The shear lip of structural nozzle S/N 0000001 was modified to permit mating with the titanium pressure vessel, and an "O" ring groove was machined into the nozzle face flange.

E. KIWI-B NOZZLE S/N 001K

Investigation continued of the Kiwi-B S/N 001K nozzle failure during simulation test firing. The prime suspected cause for this failure is a combination of thermal shock stresses and geometrical discontinuities in the brittle low stresses, due to internal pressure, which exceeded the fracture strength of the material. The mechanical properties evaluation indicated the jacket to have an average elongation of 1 %

F. ROLL CONTROL NOZZLES

This effort is being delayed until Contract Year 1964.

G. HYBRID NOZZLES S/N 001H AND S/N 002H

Hybrid nozzle S/N 001H was shipped to Howard Foundry, Chicago, for casting.

The thermospray on hybrid nozzle S/N 002H was removed, and the nozzle was hydrotested and held in readiness for casting pending selection of the vendor.

H. ALTERNATE NOZZLE DESIGN

Stress analyses of the "U-Tube" nozzle for chemical simulation and reactor firing conditions are 70% completed.

One "U-tube" nozzle forging is being machined at Marquardt, Ogden, Utah, and Aerojet is scheduled to receive a forging in July. The machine for machining grooves in the forging was shipped to Aerojet LRP from the Aerojet Downey plant. A "U-tube" nozzle brazing test sample was completed and will be assembled with end closures. The test sample will then be subjected to proof and leak tests, and then to failure.

J. HYBRID NOZZLE - ACFI PRESSURE VESSEL HYDRO TEST

The final report of the NERWI hydrostatic test is in publication.

K. APPLIED RESEARCH

During this report period, tests were completed on the reaction of graphite with H_2-O_2 combustion products, and analysis of the data was continued. Difficulty was experienced in obtaining the high mixture-ratio (MR = 6), high chamber-pressure data, as the nozzle required rework after each test due to local yielding of the metal. Because of the delay in completing the tests, the completion of the analysis of the data (Milestone 14) has been rescheduled for the 1st of August.

Fabrication of the test hardware for the nozzle hot-gas heat-transfer tests was completed.

Fabrication of the hardware for the bottom support plate tests is 95% complete.

Work on correlation of the liquid hydrogen heat transfer data was continued.

L. NRX-A PROPELLANT INLET LINES

The internally restrained bellows were ordered. A design layout of a propellant inlet line for the Rocketdyne RN-6 nozzle interface was initiated. Cost estimates from outside vendors were obtained for fabrication of this line. Stress and heat-transfer analyses for the above lines were initiated.

M. NRX-A NOZZLE CAMERAS AND LIGHTS

As stated above in paragraph B,2, the NRX-A1 nozzle is being modified to include three ports; 2 ports for one light each, and 1 port for both TV and movie cameras The cameras will be positioned to view more of the core face than was seen in the Kiwi-B4 cold-flow-test movies, including more of the core center area. The lights will be positioned to give a "stereo-type" light effect. Diffusion plates will be used to provide the desired lighting effects. The windows for the camera and lights will be purged with GN_2 during ambient flow conditions, and GHe under cryogenic flow conditions, to eliminate fogging. It is not known how valuable the addition of a TV camera will be to the cold-flow experiment. However, based on vibration tests run at the San Diego facility of the TV camera vendor, it was shown that for vibrations between frequencies of

20 to 29 and 32 to 58 cycles per second at 1/8-in. amplitude, initial displacements of a box secured to the table could be visually observed on the TV screen. It was thus shown that there exists some combination of frequency and amplitude of vibration that yields a dead-band area on the TV screen at both the video scan rate and some harmonic of the video scan rate. It is believed however, that the use of a TV camera will supplement the instrumentation in determining possible core vibration conditions in future reactor cold flow tests.

Item 1.5 ENGINE CONTROLS

A. CONTROL SYSTEM ANALYSIS

The engine start-up transients (reported in sub-subtask Item 1.1.6) were examined closely from the control system point of view. Effort is underway to modify the engine controls to produce faster and sharper start-up transients, thereby improving control effectiveness and engine efficiency.

Planning is continuing on methods of tieing the cool-down model in with the power range model. It will be possible, with the integrated model envisioned, to run the entire engine operating sequence at one time. This integrated model will include two-phase flow and the best heat-transfer and pressure-drop correlations, and will be used with the cold-flow test results to check the overall simulation accuracy. It is necessary to achieve this capability in order to properly check out the engine programmer.

The dynamic analysis of the ETS-1 control system is continuing. The balance of component information required for the steady-state analysis of the GN_2 Cool-down System (namely, valve equations and characteristic curves for non-linear valves) have been received Steady-state calculations were made to determine pressure-drop ranges of individual components in the liquid line of the mixing system to the branch shut-off valve down stream from the mixing section Calculations were made of the atomizer flow area combinations required to restrict the curve of atomizer pressure drops as functions of flow rate to a reasonable variation band.

B. REACTOR CONTROL SYSTEM DESIGN

Fabrication drawings of the NRX reactor control system have been completed with fabrication well in progress.

The item (the individual drum controller unit) required for the operation of NRX-A1 is complete, including the Test Cell "A" integration wiring diagram and the operation and installation manual.

A modified Schmitt Trigger has been designed utilizing a 20-volt dc supply, and has been proven operational under a temperature environment of 24 to -55°C. Drifts in switching point and hysteresis have been minimized by incorporating a signal input impedance to the Schmitt Trigger in the order of 1000 ohms.

The results of the analog computer program on the Kiwi-B4 control system, which was run in May, indicated a stable operation for the NRX-A reactor in the power ranges between 1 and 100%. Improvements have been incorporated in the reflector model and the NRX core model. The revised analog problem includes the latest changes and is in process on the computer. Present indications are that the previous results obtained in May are still valid.

A computer model of a gas mixing chamber is being developed. The chamber is to be supplied by LASL to provide single-phase cryogenic temperature gas for the NRX-A tests. The model is now on the computer for debugging. The gas-mixing model, when combined with the feed-system model, will duplicate the conditions LASL is using at the Test Site to test the mixing chamber.

C. ACTUATORS

1. TPCV Actuator and Drive Amplifiers

Bendix Model NT-B4, TPCV Actuator S/N 9 and Drive Amplifier S/N 5, were shipped from REON to LRP for integrated actuator-valve development testing.

Fabrication was in progress at REON on the test console and cables for the August 1963 TPCV actuator radiation test.

Fabrication was initiated at REON on a hot valve simulator to be used in thermal tests on the TPCV actuator at the REON actuator at the REON actuator test stand.

Modification and instrumentation of the REON actuator test stand was started in preparation for the TPCV actuator thermal tests.

A proposal was received from General Electric on a piston type TPCV actuator. During the month of July a contract is expected to be let after review and negotiation with General Electric.

Delivery of the TPCV Actuator Model NT-B4, S/N 10, was made by Bendix to REON on 28 June 1963. Because this actuation subsystem is scheduled for radiation testing, thermocouples were installed at four locations within the actuator.

A TPCV torque motor (Midwestern Model 39-3) was subjected to vibration testing at Bendix. The test revealed resonances at several frequencies, but performance (including resonance) was considered satisfactory in all planes, over the NERVA engine operating frequency spectrum at inputs of between 5 and 10 g.

The results of the May radiation test on TPCV actuator and amplifier components are discussed in Bendix Report 863-4-1493R. The torque motor exhibited a permanent shift in the positive direction at the end of the test. A post radiation inspection may provide an explanation for this effect. The feedback potentiometer, Markite type 8038, showed a decrease in total resistance after irradiation. However, the linearity remained within $\pm 1.0\%$.

Engineering details relative to the contracts for the design and fabrication of six second-generation prototype electro-pneumatic actuators have been completed.

The final report (WANL-TNR-112) was released for distribution during this report period.

Work is continuing on the design of test fixtures and special test equipment which will be employed for the actuator component testing.

Fabrication, assembly and checkout of the test assemblies have been completed. The test equipment will be employed in the radiation tests of the actuator subassemblies at Fort Worth, Texas.

Hydraulic subassemblies were evaluated at the supplier's plant and are being assembled with other actuator parts at the ACFI plant. Testing of the complete actuator assemblies is expected to be conducted in the first half of July.

Testing, installation and checkout procedures for the NRX-A 1 hydraulic actuators were reviewed for the testing at ACFI, and for the installation and checkout at NTS.

D. SYSTEM AMPLIFIERS

The first set of experimental system amplifiers, utilizing sheet metal containers, was shipped by Bendix. The PSA and TSA preamplifiers were tested for linearity, gain, and null shift under -175 to +125°C temperature environment with line voltage and frequency variation of ±10%.

Linearity remains within ±0.35% for test conditions, but gain and null shift varied 4% under extreme temperature.

E. PROGRAMMER AND REMOTE ENGINE CONTROL

The wiring diagram for the Ground Test Programmer portion of the Remote Engine Control System Simulation has been initiated. Malfunction circuitry will be added to this diagram as the design requirements are defined.

A preliminary functional diagram of the Cold-Flow Development Test System controls and sequencing has been completed. Coordination meetings with AGC-LRP test personnel and facility inspection are planned to assure final establishment of design requirements for the CFDTS engine sequencer.

F. ENGINE HARNESS

Rough drafts of the anticipated harness schematics and harness design requirements were completed for the E-Engine by LRP in the month of June.

A thermal analysis was also completed of a quartz insulated cable for the E Engine, and the results will be published next month.

Item 1.6 DESTRUCT SYSTEM

A. BASIC FRAGMENTATION RESEARCH

There were no major tests conducted in studies of either material correlation or fracture mechanism, since a number of the additional tests planned in these areas are awaiting the receipt of more realistic GFE fuel element material.

Experiments were conducted, as part of the fragmentation research program, to provide an additional basis for performing an analysis to evaluate the adequateness and further utility of the full-scale simulated targets currently being used in ACDS and PODS concept tests.

It is known that the performance of the various ACDS and PODS destruct system concepts is greatly affected by the reactor design. Therefore, it is extremely important not only to provide as accurate a simulated target as possible, but also to carefully consider the construction and materials of the simulated NERVA engine targets in evaluation of the test results.

1. Mark D/J ACDS

The capability of the core material to transmit radial load outward from the destruct charge to the pressure vessel is a factor which would vitally affect the performance of the Mark D/J ACDS. A test was therefore conducted to obtain a comparison of the load transmission properties of solid graphite rods and hexagonal graphite rods with a B-1 hole pattern (simulated Kiwi B-4 products were not available). This comparison was obtained by assessing the degree to which steel cylinders would be deformed by explosively generated rods transmitted through separate clusters of each type of rod. Mild steel cylinders 6-in.-I.D. by 6-in. with wall thickness of 0.25-in. were filled with core elements of one or the other of the above mentioned types, and a 5/8-in. diameter Composition B explosive charge was positioned in the center of the cluster.

After detonation of the explosive charge, the damage contour of the deformed cylinders was measured, and the energy of deformation obtained by a numerical integration of the conventional stress-strain curves along the length of the cylinder. The deformation-energy ratio of the solid rods to the hexagonal rods with Kiwi B-1 hole pattern was 1.33, indicating the greater load transmission capability of the solid round rod. It is anticipated that the load transmission ratio would be greater if 3/4-in. round rods were compared with Kiwi B-4 elements, since the B-4 element is more fragile, and has more than twice the void volume because of the greater number of coolant holes.

In addition to the core material, the analysis also considered the effect of the pressure-vessel component of the simulated targets, since this component is an important factor for consideration of concepts which apply their explosive energy from an internal or an external point of attack. In the case of the Mark D/J ACDS, it would be necessary to rupture the pressure vessel by the action involved in the radial movement of core materials and detonation products in order to permit adequate dispersion of the core material.

Tests performed to date have employed simulated pressure vessels made from 1-1/8 in. thick 6061-0 aluminum and 6061-T6 aluminum in both 1-1/8- and 0.8-in. thicknesses. The NERVA pressure vessel is currently specified as 6061-T6 aluminum of 0.67 in. thickness. Ratios were derived for the energy required to rupture the actual pressure vessel compared with the energy required to rupture the simulated pressure vessel of the thicknesses and hardnesses specified above.

These calculations indicated that the actual pressure vessel would be easier to rupture than any of the simulants used. The rupture energy ratio of the pressure vessel with a wall thickness of 0.67-in. to the simulated pressure vessel of 1-1/8 in. thick 6061-0 aluminum, was shown to be 0.46. When compared to simulants used from T-6 aluminum of 1-1/8 in. and 0.8 in. thicknesses, the ratios were 0.59 and 0.83 respectively. From a consideration of the inter-relationship of the energy ratio required to rupture the pressure

vessel and the capability of the core material to transmit the explosively generated energy, it is possible to arrive at new ratios which take both of these factors into account and represent approximations of the relative energy required. These tentative values would indicate that dispersion of the NERVA reactor would require [illegible] losive energy than targets using the 1-1/8 in. thick simulated pressure vessel and solid round core rods, but more energy than the targets using 0.8 in. thick pressure vessels and round core rods. However, future tests with Kiwi B-4 core material might indicate that the energy transmission characteristics of this material are such that destruction and dispersion of the reactor core would require more energy than that required for destruction and dispersion of a simulated engine target using the 1-1/8 in. thick aluminum pressure vessel.

This analysis serves to emphasize the need for Kiwi B-4 material in sufficient quantity to conduct tests which would provide a comparison of the load transmission capability of the B-4 material with the solid round graphite rods used in the simulated engine targets.

2. Mark A ACDS

In the case of the Mark A ACDS concepts, the load transmission properties of the core material would not be major factors for concern since large pressure-vessel rupture loads would not be required. The pressure-vessel material itself would have only a minor effect on linear shaped charge size. The overall effect of the magnesium simulated reflector segments on design changes which might affect the cooling channel spacing would be to change the size of the linear shaped charges which provide the required deep penetration into the core material.

It is felt that the Mark A ACDS concept requires only light cutting by the linear shaped charges. Consequently, their size should vary only slightly when the system is designed for the destruct of the actual NERVA engine.

However, the load transmission properties of the core are of some importance with the use of this concept, since it is anticipated that the internal support cylinder would not be cut by the linear shaped charges. Failure to rupture this internal support cylinder would effectively reduce the dispersion of the core material, unless some significant increase were made in the size of the delayed aft entry dispersal shaped charges in order to increase the lateral energy effects derived therefrom. The expected load transmission properties of the B-4 element (as compared to the solid round rods) would probably be more critical in the use of the Mark A concept than for the Mark D/J concept. This is based on the hypothesis that the conical shaped dispersion charge does not transmit radial loads of sufficient intensity or duration to compensate for the large difference in load transmission capabilities which probably exist between the simulant and actual core elements. This presumption was supported by the test results obtained in Test AC-155, which used two large dispersal shaped charges with intersecting jets to increase these lateral energy coupling effects.

B. RADIATION EFFECTS EXPERIMENTS

A series of tests were performed as part of the continued development toward achieving a means of sealing an irradiation capsule against gas leakage when 3 grams of explosive are detonated within the capsule. Several types of gaskets and sealing techniques were evaluated under both static and dynamic pressures.

Although some types of gaskets were eliminated from further consideration due to their inability to withstand high static pressures, other soft metal gaskets provided sealing with no leakage greater than 2×10^{-10} cm^3/sec at an internal capsule pressure of 10,000 psi. The capsule sealing capability was enhanced by tightening, to 200-in.-lb of torque, the cap screw attaching the lid to the body.

Tests of the dynamic sealing capability of the capsule were conducted by impact detonating 3 grams of PETN sealed in each capsule, then measuring the gas retained by removing the capsule lid under a water displacement apparatus. Two successful tests made use of an aluminum "blast cup"

inverted over the gas expansion chamber, in addition to soft metal gaskets. Detonation of the explosive caused the cup to form into the capsule body-lid interface, thus sealing the high-pressure surge of gas. Although these tests indicated little or no leakage when the retained gas was compared to the theoretical quantity of gas generated, future tests, in which the capsule will be impact-detonated while under the water displacement apparatus, will provide positive indication of the capsule sealing capability.

C. MECHANICAL FEASIBILITY STUDY

1. Disposal of Jettisoned Shaped Charges

A study was conducted to determine the problems associated with the disposal of jettisoned shaped charges used in an ejectable ACDS. These charges must be destroyed prior to impact with the earth. However, it is believed that detonation within 5000 feet of the vehicle could result in damage to the vehicle. Some devices or techniques which were considered to achieve disposal of the charges included time fuses, proximity fuses or ranging radar, barometric pressure fuses, and auto-ignition of the charge through re-entry heating. The simplest method appears to be by use of time delay fuses, which can function on pyrotechnic, chemical, electric, or mechanical principles. Further analysis and evaluation will be required before the most suitable disposal technique can be selected.

2. Mark D PODS

A preliminary evaluation of the mechanical feasibility of a Mark D PODS using a single projectile was made. The analysis was made with the assumption that the core fragmentation achieved by the single and multiple charge systems having the same explosive weight, would be approximately equivalent.

In general, the analysis indicated that a single projectile PODS is less feasible than a multiple projectile system. The analysis showed the total weight of a single projectile system using a titanium gun and the explosive weight of 4-13⅞ mm projectiles, to be 3476.2 lb, as compared with

2298.9 lb for the equivalent multiple projectile system. The weight for a single projectile system having the explosive weight of 6-155 mm projectiles was calculated as 4783 lb as compared with the equivalent multiple projectile system weight of 3571.2 lb.

Due to the magnitude of concentrated mass, a single projectile system would require an exorbitant parasitic counterbalance weight or a major relocation of external engine equipment to provide overall static and dynamic balance.

3. Linear-Shaped Charges

A series of 18 tests was conducted to determine the effects upon linear shaped charge performance of wave shapers, variations in standoff, and different modes of initiation. Each of the 90° angle 2-1/2-in. wide charges was loaded with Octol and its performance evaluated by firing it against a 6-in. thick steel witness plate. The 9 charges using wave shapers contained approximately 57% less explosive than the charges using no wave shapers. Stand-off distances ranging from 0.4 in. to 2.5 in. were evaluated. Three modes of initiation were tested: initiation from one end, initiation at the charge center, and initiation along the entire length simultaneously, by use of a line-wave generator.

Although better performance was obtained with the charges not using wave shapers, the results showed promise for the wave shaped charges, when consideration was given to the fact that they contained 57% less explosive than the other charges.

The best performance was attained at a stand-off of 1.5 in. with the shaped charges containing wave shapers and at 2.0 in. with the shaped charges without wave shapers. In comparison of the effects of the different modes of initiation, it was shown that the charges initiated from one end gave the best results.

D. ANTICRITICALITY DESTRUCT EXPERIMENTS

Two ACDS tests were conducted using full scale targets. One target was used in testing a Mark C (AC 161) destruct system concept and the second

target was expended in the evaluation of a Mark A (AC 155) destruct system concept.

a. Mark A Tests

Recently conducted Mark A tests (AC 131 and AC 133) which did not completely satisfy the destruct criteria, indicated that this goal would be attainable with a Mark A destruct concept if slight modifications were employed. Consequently, AC 155 made use of linear cutting charges of reduced power, two 10-in.-dia conical shaped charges rather than one 6-in.-dia charge, and a reduction of delay from cutting to dispersion charge initiation to 100 microseconds.

A linear cutting charge was employed to provide a single circumferential cut of the pressure vessel and to sever the reflectors from their support rings. Four sections of linear shaped charge were used to sever the pressure vessel into 4 longitudinal sections. The conical charges were positioned on the nozzle diametrically opposite each other with an 8 in. stand-off to the nozzle surface. The total explosive weight was 290 lb, of which 240 lb was contained in the 2 conical shaped charges. The linear cutting charges used Octol as an explosive, and Composition B was used in the conical charges.

The modifications incorporated in this destruct system resulted in achievement of the ACDS criteria The maximum concentration of core material sampled in a 25 in. circle weighed 0.65 lb. The majority of the core was scattered over a 65 x 480 ft area.

2. Mark C Tests

The test of the Mark C destruct concept made use of 4 conical charges of 8-in. diameter, using wave shapers. Each charge was loaded with 25 lb of Octol explosive. The charges were positioned on the simulated nozzle at stand-off distances of 3, 6, 9, and 12 ft and oriented in such manner that their axis would penetrate the core and intersect the pressure vessel at the forward top surface of the core. Although the charges were initiated simultaneously, the differences in stand-off caused the shaped charge jets to strike the core at approximately 100 microseconds intervals.

Following detonation of the charge it was found that the walls of the pressure vessel failed to rupture. Consequently the core material was not dispersed. Because of the poor results from this test and previous Mark C concept tests, it was concluded that further testing in support of the Mark C concept should be suspended.

E. POST OPERATION EXPERIMENTS

Three tests were conducted in support of the PODS development. One test employed a full-scale half-length target to evaluate the effectiveness of a single internal burster charge (PO 96) containing explosive equivalent to 4-105 mm projectiles. A second test (PO 91) using a full-diameter half-length target, investigated the effect of prolonged delay between initiation of each of the 4 internal burster charges used in a Mark D PODS. The third test was performed with a sub-scale target, to determine if detonation of one internal burster charge would cause sympathetic detonation of a similar charge in full-scale Mark D tests.

1. Test PO 96

Test PO 96 was conducted to determine the effect upon core fragmentation of concentrating the destruct systems explosive into a single charge rather than distributing it into a number of charges. The single charge contained 6.55 lb of Composition B cast into a 26-in. length of 8.75-in.-OD steel tube with a 0.75-in. wall thickness.

The amount of explosive and the target were similar to previous tests in which four internally placed charges simulating 105 mm projectiles were used. The single charge was positioned at the center of the target.

Analysis of the test fragments showed the average particle size to be approximately 0.5-in. mesh, which compares favorably with the results obtained from previous tests using multiple charges. However, the previous tests produced larger quantities of particles smaller than 0.0394-in. mesh, and were therefore considered to be more promising. No further tests of the single internal burster charge are planned, principally because of the mechanical feasibility problems which are associated with this destruct concept.

2. Subscale Test

A subscale test was conducted to determine if the detonation of an explosive charge would result in detonation of an adjacent charge, in a multiple-charge Mark D destruct system. In this test, two 10.6-lb charges of Composition B explosive simulating 105 mm projectiles, were placed 11.2 in. apart and parallel in a box filled with 3/4-in. graphite rods simulating the core. One charge was detonated with an electric detonator. Examination after the test revealed that the other charge casing was destroyed and the explosive dispersed over the immediate vicinity, although the explosive did not detonate.

The results of this test indicated the feasibility of conducting a test in which relatively long delays between the initiation of each charge could be used, without sympathetic detonation of charges.

3. Test PO 91

As a result of the foregoing tests, Test PO 91 was conducted to determine the effect upon core fragmentation of a prolonged delay between the initiation of each of the four charges. This test employed four 105-mm internal burster charges, each containing approximately 10 lb of Composition B explosive, statically emplaced in a full-diameter, half-length target. A separate firing panel and detonator was used to initiate each of the four charges. The charges were to be initiated at 3.5 millisecond intervals through use of electronic time delays. However, the initiation of charge 4 inadvertently occurred 0.5 millisecond after the initiation of charge 3. The total time lapse between the initiations of the first and last charges was 7.5 milliseconds, as measured by an electronic digital time measuring instrument.

Examination of the test fragments revealed no marked difference from the test fragments that were obtained in a previous similar test (PO 95) in which the charges were simultaneously initiated.

Item 1.7 PNEUMATIC SYSTEM

The pneumatic system design criteria for the cold flow development test system were completed during this report period. Based upon these criteria, a system layout drawing was prepared, thus forming the basis for establishing line lengths, and permitting the sizing of the tubing. Steady-state point conditions are presently being calculated.

Initial investigations into filters for use in the CFDTS indicate that the stipulated 10-micron size will be difficult to obtain.

Pneumatic system schematics for engine blocks E-1, E-II, E-III, and FX were prepared to facilitate the long-range direction of the Pneumatic System development program. Layout of the pneumatic system for the E-1 engine was initiated. The following work was accomplished on components:

1. The test stand pneumatic connector specification is in the process of preparation. The design of the gland has been initiated.

2. The burst diaphragm specification was initiated.

3. The relief valve specification is being released.

4. Specification control drawings were completed on the 1/2 and 1-1/4 in. filters, the 3/4-in. regulator, and the relief valve.

5. Requests for vendor quotation have been made for the following items:

1/2-in. shutoff valve

3/4-in. shutoff valve

3/4-in. check valve

1-1/4-in. check valve

Item 1.8 NRDS OPERATIONS

A. ETS-1 ACTIVATION

A meeting on 11 June 1963 established that operational checks to verify the integrity of contractor-installed systems on ETS-1 would commence on 1 October 1963. Procedures to accomplish the program are being prepared, based on a recently imposed constraint on the use of the high-pressure storage vessels. V-5201 through V-5206, operating at maximum pressure of 1000 psi. A detailed outline for these operational checks will be submitted to SNPO-C for review on, or about, 15 July 1963.

The as-built dimensions required for design of the liquid-level probe of vessel V-5001 were obtained by actual field measurement, and were given to the Catalytic Construction Company for transmittal to SNPO and REON. Coordination continued with Sections of REON on the Facility Controls System.

B. TEST CELL A OPERATIONS

Installation of the mixing chamber and the new reactor purge line was completed. Several instrumentation and flange leaks were repaired, after pressure testing the equipment. REON test operations personnel assisted with the mixing chamber tests conducted 27-28 June 1963.

Item 1.9 RADIATION EFFECTS PROGRAM

A. PROGRAM PLANNING

The radiation effects testing program for Contract Year 1964 has been outlined and the Work Statement, Technical Administration Document, and the General Dynamics/Fort Worth Program Planning Details are being prepared. These documents will be published in July.

B. RADIATION EFFECTS REPORTS AND INFORMATION

A report entitled Irradiation Effects on Selected Lubricants Materials WANL-TNR-109, was generated as a final report on test 40/W002 in the Radiation Effects Program.

The following documents were issued for insertion into REON Report 2510, Radiation Effects Testing:

1. Final Test Plans

5/A001	TPCV Actuator
39/W201	Fuel Materials
39/W202	Fuel Materials
23/W103	Resistance Thermometers
23/W301	Thermocouples
23/W401	Strain Gages
39/W102	Fuel Materials

2. Preliminary Test Specs

5/A001	TPCV Actuator

3. Final Test Specifications

39/W001	Fuel Materials
39/W101	Fuel Materials
39/W102	Fuel Materials
39/W201	Fuel Materials
39/W202	Fuel Materials
8/W001	Transition Joint
23/W201	Displacement Transducers

4. Preliminary Test Report

30 W001	Shield Materials
21 W002	Neutron Detectors
25/A002	Strain Gages
27/A002	Amplifiers
31/A002,5, [illegible]	Electronic Components

REON Report 200, Final Test Specification for Ground Test Reactor (GTR) Test of July 15, 1965 was issued. This report contained final test applications for the following radiation tests:

21 W005	Neutron Detectors
22/W007	Neutron Detector Preamps and Cables
25/A002	Pressure Sensor (ICA)
27/A005	Amplifiers
31/W012	Electronic Components

C. NUCLEAR ANALYSES

Evaluations were completed on the primary and secondary gamma radiation environments of the NERVA engine.

D. RADIATION EFFECTS TESTING PROGRAM - COMPONENTS

1. Electrical Components

Electrical Test Pallet 501 system drawings were updated, and the pallet is approximately 60% fabricated. Mating electrical connectors required at GD/FW for this pallet were shipped to Fort Worth.

Electrical Test Pallet 502 electrical schematic drawings were completed and fabrication is beginning.

Electrical Test Pallet 503 preliminary design requirements were received and are being reviewed.

2. Mechanical Components

Detail design continued for the Control and Mechanical Pallets, required for the TPA Bearing Tests 901, 903, and 905.

Liaison continued with GD/FW for the checkout and installation of Mechanical Pallet 901. The pre-irradiation checkout tests of this pallet continued.

Long-lead procurement and fabrication for all CY 1963 pallets, and for Mechanical Pallets 905 and 906 continued.

3. Test Facilities Special Test Equipment

The design of the GD/FW gas distribution and electrical systems was completed.

The LH_2 piping, the two control racks for the gas distribution system, the Dewar, the electrical system, and the flex lines have been installed at GD/FW.

The following was accomplished on the W-1 Cryogenic Loop and the W-2 Water-Cooled Loop at PBRF during the reporting period:

The design effort of the W-1 loop by Vitro Engineering Co. was completed. PBRF has approved the design package.

The design of the W-2 loop was completed, and procurement of individual items was completed. Some of the piping to be installed was pre-fabricated and shipped to PBRF and installation was initiated. Associated piping is also being installed.

A draft version of the W-2 loop Design and Hazards Summary Manual was prepared and submitted to PBRF for approval.

A draft version of the W-2 loop Operational Manual was prepared and is being presented to PBRF for approval.

E. MATERIALS PROGRAM - NON-NUCLEAR

1. Non-Radiation Program

a. Reactor Materials (Non-Fuel) (Item 1.3.1)

(1) Shield Materials

The irradiated capsules have been received at the WTR hot cells, where they will undergo post-irradiation examination. The flux monitor wires have been transferred to WAPD radio-chemistry for analysis.

(2) Reactor Structural Materials

Developmental production is continuing on gadolinium-bearing stainless steel type 304, for cluster plates. A 400-lb heat of air induction-melted material was produced, and chemical analyses at several locations indicated that the gadolinium content was uniformly distributed within acceptable limits. However, as in the case of larger heats, this 400-lb ingot was not forgeable. A 50-lb heat was produced and satisfactorily forged, but chemical analyses have not been completed. Small 17-lb heats have shown satisfactory tensile properties. Additional efforts to solve the cluster-plate problem include the following plans:

Investigation of production of gadolinium-bearing stainless steel by powder metallurgy, followed by rolling.

Investigation of the use of gadolinium foil for sandwich-type construction.

Investigation of vapor-deposited gadolinium for sandwich-type construction.

Investigation of availability and properties of stainless steel which contains Boron-10.

Evaluation of silver-indium-cadium alloy (80 Ag-15-In-5 Cd). This has been found satisfactory in vibration, cold-flow, and PAX experiments.

Procure and evaluate a small quantity of gadolinium-bearing stainless steel for use in the PAX experiment.

(3) Control Materials

Manufacturing of control drum plates has continued. Seven Al_B (80% Al-20% boron-10) compacts were hot pressed, and five were canned for rolling. Thirty Al_N (80% Al-20% natural boron) plates have been formed and will be punched when new tooling is available. Thirty formed and punched Al_N plates have been given serial numbers and identification by electrolytic etching. Eight of these are scheduled for anodizing and dyeing to determine any possible changes in dimensions or in legibility of identification. In addition, 15-lb of natural boron powder was received, sampled, and seived.

(4) Instrumentation

The problem involving changes in calibration of tungsten/tungsten-rhenium thermocouples due to service conditions is being investigated from the standpoint of impurity pickup from beryllium oxide, or from the graphite matrix. Instrument suppliers have been contacted to assist in selecting more reliable designs and materials for use in cryogenic-irradiation environment.

b. Thrust Chamber Assembly

(1) Cast Aluminum Jacket Materials Development

Tensile properties, chemistry, and microstructure were determined for the A-356-T6 jacket of Kiwi-B nozzle S/N 001K, and tests on notched-tensile specimens are in progress at both 75 and -320°F. Average room temperature tensile properties were: 29.2 ksi ultimate, 27.4 ksi yield strength, 1.65% elongation (in 4D). Chemical composition was normal except for high copper. Microstructure was poor, showing gas-porosity, microshrinkage, and coarse acicular particles. Tensile properties were also determined for jacket materials of NRX-A nozzle S/N 00000-, and HYBRID I nozzle S/N 001H. Metallographic analysis was completed for jacket material of NERVA nozzle S/N 001N.

Howard Foundry of Chicago produced separately cast test bars which were tensile tested and examined metallographically. Experimental test bars were also produced at Pacific Brass Foundry to evaluate A-356 aluminum alloy containing four different levels of magnesium and cast in five different thicknesses. Tensile properties, chemistry, and metallography are in process of evaluation. Preliminary indications are that tensile strength varies directly with magnesium content for sodium - innoculated material. The effect of composition on ductility was not determinable due to casting defects.

(2) Braze Alloy Development

A tentative brazing procedure for U-tube nozzle design was presented to SNPO personnel at Washington, D.C. The first U-tube simulated throat specimen A-1 was fabricated using NIORO Braze alloy

(12 AU-18 Ni), and X-ray standards are being developed for quality control. Hydrostatic proof testing of this sample has been scheduled.

Stainless-steel Type 347 shear-test specimens (2T) were prepared, using NIORO braze alloy. All failed in parent metal when tested.

(3) Thrust Chamber Assembly Materials Investigation

Alloy A-286, received from Standard Pressed Steel Company, was scheduled for machining of tensile specimens, and metallographic examination of this material is in progress.

Tensile specimens of Inconel 718, cold drawn and aged, have been ordered from Voi-Shan, Inc., and delivery is estimated at six weeks.

(4) Pressure Vessel Materials Department

Welding was completed on titanium alloy 6Al-4V ELI forged plates for evaluation of tensile properties.

Preliminary data were released for tensile tests of this basic material, performed by Aerojet at room temperature, -100, -320, and -423°F. Tensile data were also released on specimens of titanium alloy 5Al-2.5Sn ELI taken from a forward closure, several cylinders, and an aft-adapter of pressure vessel forging 001 TFV.

(5) Materials Data Book

Preparation of graphs, design properties, and fabrication information on structural materials is continuing. The second supplement will be issued in July.

(6) Twenty-nine process specifications and thirty-five purchasing specifications for WANL were reviewed, and comments were forwarded for their revision and resubmission.

2. Irradiation Effects on Structural Materials (Item 1.9.6)

a. Tensile and Shear Test

Preliminary results have been obtained on the ultimate shear strength at liquid hydrogen temperatures on the control shear specimens of all structural materials scheduled for this contract year. Following data are presented:

ULTIMATE SHEAR STRENGTH AT -423°F

Material	Shear Strength, psi	Number of Tests
ALUMINUM ALLOYS		
A-356-T6	50,400	4
2219-T81	72,300	4
5456-0	53,600	2
5456-H321	58,500	3
6061-T6	49,800	4
7075-T6	95,200	4
7079-T6	69,500	4
STAINLESS STEEL		
304 annealed	141,000	4
321 annealed	133,400	4
347 annealed	152,400	4
347 cost	163,400	3
17-7 PH (RH950)	180,000	3
AM 286, age hardened	168,200	4
410 hardened	149,300	3
TITANIUM		
Alloy A110-AT	130,600	4
NICKEL BASE ALLOYS		
Hastelloy C	149,200	3
Inconel X-750	152,800	4
Inconel 713C (Cost)	144,500	4

All tensile and shear specimens which were partially irradiated during the second radiation run conducted at the end of March 1965 (with the exception of the Teflon and Armalon) are stored at General Dynamic/Fort Worth Facilities. The irradiated Teflon and Armalon specimens were tested at liquid hydrogen temperature after a warm-up period. The obtained average tensile strength is 8160 psi for Teflon and 20700 psi for Armalon, with an average elongation 1.5% and 2.5% respectively. The data reduction or the control tensile test is not complete.

Detailed drawings on the new Dewar design are being prepared. These drawings will be submitted to SNPO-C for approval.

b. Thermal Conductivity Test

The first thermal conductivity test over the temperature range from 20-100°K has been completed with prototype equipment for checkout purposes. Manufacture of the equipment to be used in irradiation tests using this design is scheduled to begin during July.

DECLASSIFIED

SECTION III (cont.)

TECHNICAL DISCUSSION

TASK 2.0 ENGINE SUPPORT SYSTEMS

DECLASSIFIED

Item 2.1 REMOTE HANDLING EQUIPMENT

A. INTEGRATION AND TECHNICAL MANAGEMENT

Two Design Review Meetings were held with AMF, the first, 12-19 June, and the second, 25-29 June. The purpose of the meetings was to upgrade equipment specifications; to review purchase packages on the MCC shielded cab, OPS bridge and trolley, and the OPS mast; to review PERT networks for problem areas; and to clarify interfaces between AMF equipment, the NERVA Engine, and E-MAD facilities.

The operational flow for transferring the pressure vessel from the LRP cage (Provisioning List Item N-914) to an ACFI cage in the R-MAD Building was the primary topic of discussion at a meeting held at LRP on 11 June. It was agreed by LRP, WANL, and ACFI to remove the pressure vessel from the trailer and rotate it with the ACFI Universal Handling Fixture. This procedure will be used for NRX-A1 only.

REC/AMF liaison was intensified permanently in June to keep pace with AMF's expanding activities in purchasing and final design. This was decided upon because of the greater attention to detail required as major contractual milestones approach.

B. OVERHEAD POSITIONING SYSTEM (OPS)

Bids on the OPS bridge and trolley were requested from vendors. The mast design was completed and will be ready for bid solicitation in early July.

C. FLOOR MOUNTED HANDLING SYSTEM (FMHS)

Final design of the mobile carriage, dolly, and turntables is 80% complete. FMHS stand designs are being held in response to SNPO direction.

D. NRX EQUIPMENT

LRP has been directed to provide the dummy forward closure, nozzle closures, and the special, three-legged sling, as required by the late delivery of these NRX-A1 and A2 items. A Project Directive delineating this responsibility is in preparation.

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A status summary of the NRX-A1 Support Equipment follows:

WANL

Provisioning List Item No.	Title	Status
1102	Tool - control-drum bearing-housing bolt removal	Final design initiated
1106	Handling fixture - outer reflector assembly	In fabrication
1108	Tool - outer reflector tie-bolt nut removal	Final design initiated
1125	Tool - cluster-nut removal	Bid package in process
1169	Tool - shim-rod-nut removal	Final design initiated
1191	Tool - core-support ring-bolt removal	Design layout in process
1206	Tool - cluster-nut removal (0-man adapted)	Bid package in process
1215	Tool - spring retaining bolt removal	Design criteria in development

WANL, ACFI

1131	Handling fixture, universal	In fabrication
1135	Handling fixture, shield	In fabrication
1138	Stand, privy plug assembly	In fabrication
1147	Trunnion cage, reactor	In fabrication
1150	Trunnion cage, reactor-vessel	In fabrication
1151	Handling fixture - reactor adapter ring	In fabrication
1153	Handling fixture - screen	In fabrication
1180	Tool - instrumentation seal-nut removal	Required for disassembly operations only. NRDS use
1181	Support fixture - instrumentation and control shaft	In fabrication
1182	Fixture - reactor trunnion	In fabrication
1187	NRX-A1 test car	In fabrication
1247	Personnel platform, Reactor-Vessel Car	Bid package in process

All support equipment for NRX-A1 is on schedule. The milestone of 6 July, which calls for completion of all NRX-A1 support equipment design releases, should be met.

The following proposed NRX-A2 WANL purchase orders were reviewed during the report period:

Provisioning List Item No.	Title	Status
1104	Control-drum assembly storage stand	REON technical approval withheld pending modification or justification of design
1149	Outer reflector support-ring lifting fixture	

NRX equipment lists were prepared for a feasibility study of E-MAD to accommodate NRX and for the Program Requirements Document (REON Report 2578).

E. NERVA EXHAUST SYSTEM (NES)

Four NES handling procedures were reviewed for a revolving gantry crane, a locomotive crane, a stiff-legged derrick, and a pneumatic tired trailer. A major effort was directed toward developing the capability of moving the duct, on the pneumatic tired trailer system, to and from the vault through the ditch. Two concepts are being studied; one requiring disassembly of the duct in the ditch, the other based on moving the duct in one piece to the storage area. Both plans are to be compared through further development.

Handling equipment requirements were developed for both methods of handling, and various configuration studies were made. Layouts of trailer configuration possibilities were made, and feasibility is being studied for both methods.

F. E-ENGINE EQUIPMENT

Requirements were investigated for providing aftercooling of an engine, beginning 24 hours after shutdown. The relationship of required heat removal as opposed to time and engine location at EIV, E-MAD, and the

Hot-Hold Stand, was investigated to establish the need for an after-cooling system at these locations.

...ree cooling systems were checked for feasibility including air cooling, ambient nitrogen cooling, and liquid nitrogen evaporator cooling. While all three systems were found feasible, further studies will be made to establish an optimum system.

Protective dust covers and contaminated-particle filters for the top and bottom of the engine are under study. Design criteria (preliminary) was established and is being checked for compatibility with the cooling system required for post-test removal and transport

Data, prints, specifications, and design criteria are being analyzed prior to preparing an engine operational support plan, and detailed operational procedures.

G. EIV, MCC, AND LOCOMOTIVE

Fabrication of the Engine Installation Vehicle (EIV) car and superstructure is on schedule.

Fabrication of the car for the Manned Control Car (MCC) is also on schedule. The bid packages for the shielded cab were sent to vendors.

A trip was made to the Lewis Research Center at Plumbrook, Ohio, to inspect the Locomotive after it had been serviced by the Army Transportation Corps. The Locomotive was found acceptable to RECN as a GFE operable item. Specifications are being revised to reflect only those changes required for NRDS operation.

H. FACILITIES SUPPORT EQUIPMENT (E-MAD COMPLEX)

A study of E-MAD local control stations, controllers, and color coding was completed. The object of the study was to provide uniform and compatible remote control equipment in the E-MAD.

Item 2.2 GROUND SUPPORT EQUIPMENT - CHECKOUT AND TEST SYSTEMS

A. INTEGRATION AND TECHNICAL MANAGEMENT

A status report of all Subtask 2.2 and 2.3 support equipment was submitted to Mr. E. Burciaga of NASA-WOO following a review meeting with him at Azusa on 21 May 1963.

B. NRX EQUIPMENT

The review of the NRX-A1 Operational Support Plan was completed at WANL and technical direction established for the completion and publication of the document during July 1963.

A status summary of WANL NRX-A1 Support Equipment follows:

Provisioning List Item No.	Title	Status
1402	Control-drum servo checker	In fabrication
1406	Wiring and transducer checker, test car	In fabrication
1411	Drum-control equipment, individual manual	In fabrication
1415	Reactor instrumentation equipment	Purchase specs completed

All items are on schedule.

Remaining WANL NRX support equipment drawings are 95% complete, and of these 60% are released.

A review was initiated of the I&C design package submitted to REON by EG&G. This data is a contribution to the development of the final design package under the cognizance of Subtask 3.3.

Item 2.3 GROUND SUPPORT EQUIPMENT - TRANSPORT, GROUND HANDLING, AND MAINTENANCE

A. INTEGRATION AND TECHNICAL MANAGEMENT

A Design Review Meeting was held at WANL, 18-20 June, to review the design and status of all NRX-A1 support equipment for Subtasks 2.1, 2.2, and 2.3. All support equipment for NRX-A1 is on schedule.

A Status Review Meeting was held at REON, 28 June, with Mr. E. Burciaga of NASA-WOO, to present the status of all Subtask 2.2 and 2.3 support equipment.

B. NRX EQUIPMENT

The WANL purchase order for the inner shipping container stand, (Provisioning List Item 1126) was received and approved by REON. WANL was notified of the approval.

A summary of WANL NRX-A1 support equipment status follows, listed by groups:

Number of Items	Group	Status
8	Receiving equipment	Fab completed on 7 items. One item in fab. All on schedule.
12	Cold disassembly equipment	Bid package in process on 7 items. Five items in fab. All on schedule.
15	Storage containers	Design complete on 2 items. 12 items in design. One item to be supplied as GFE. All on schedule.
1	Reactor shipping container	Fab completed.

C. E-ENGINE EQUIPMENT

Page and Page Company was selected to supply the Rocket Engine Semi-trailer (Provisioning List Item 724). The suspension system design is presently being coordinated with them. Due date for delivery of this item is 9 August 1963. E-engine equipment lists for the E-MAD Complex, Phases I and II, are being prepared.

Item 2.4 INSTRUMENTATION

A. INSTRUMENTATION DATA BOOK

Work was continued on the July 1963 edition of the Instrumentation Data Book. It is anticipated that the updating of measurement requirements lists, and the accumulation of additional data, will expand the Data Book into 3 volumes.

B. NRX-A INSTRUMENTATION

Specification Control Drawings for the NRX-A1 cold flow engine were updated to incorporate the latest current environmental requirements. Effort continued on the NRX-A1 instrumentation installation drawing and the NRX-A1 instrumentation schematic, incorporating changes caused by the addition of viewing holes in the nozzle. The release of these drawings is anticipated in July.

A tungsten-rhenium thermocouple was designed for use in the NRX-A-2 HF engine. One element consists of W-5% Re, by weight, and the other is W-26% Re. Thoria is used as the thermocouple wire insulating material; and the thermocouple has a tantalum inner sheath, and a W-26% Re outer sheath.

The design of a port adapter for the LASL-NRX-A thrust chamber simulator furnace was completed; preparation of fabrication drawings is now in progress. When completed, they will be submitted to LASL for review and comment.

Proposal drawings were submitted by the Aero Research Instrument Division of Advanced Technology Laboratories, Chicago, Illinois, for a high temperature exhaust thermocouple assembly to be used on the initial NRX-A Hot-flow engines. The drawings were reviewed and returned to the vendor, with approval of the design contingent upon receipt of updated vendor-drawings incorporating the latest revisions.

A summary was received from LASL of reactor instrumentation development work accomplished since the Kiwi-B-4A hot run. The information contained is being incorporated into the developmental plans and design criteria for NRX-A hot-flow engine instrumentation and transducer development activity.

C. MECHANICAL COMPONENTS IRRADIATION TEST INSTRUMENTATION

Instrumentation components were ordered for Materials Irradiation Tests 903, 904, 905; and for two control pallets. The completion of Test 902 acceptance testing is planned for July, together with fabrication of two RTT calibration sets.

D. CRYOGENIC TEMPERATURE TRANSDUCER DEVELOPMENT

A technical review was completed of the proposal for a miniature transducer submitted by Rosemont Engineering Company. This document, entitled "Technical Proposal for a Specially Designed Platinum Resistance Temperature Sensor for Shallow Immersion Applications," covers units designed to be completely interchangable within 0.5°F (including manufacturing tolerances, calibration accuracy, and repeatability). The transducers have a maximum diameter of 0.15 inches, with the sensing element in the last 0.10 inch of the probe.

Preliminary calculations were made to determine the feasibility of standardizing Electro-Optical Systems temperature transducers by adding a shunt resistor to the silicon sensory elements.

A technical review was completed on the Winsco and Electrowest quotations for five platinum resistance temperature transducers. Winsco, the low bidder, based their bid upon an unacceptable deviation from the specification (AGC 248059). Winsco will be asked to resubmit the bid without deviations from specification; and the successful bidder will then be evaluated as a potential second source of supply.

An evaluation study of thermal emf induced in Rosemont Model 134CT platinum resistance temperature transducers was initiated. Tests in liquid neon are currently being conducted.

A Rosemont Model 134EB cryogenic temperature transducer (radiation resistant design) was removed from test service after being used for dynamic temperature measurements in liquid hydrogen during more than 15 engine component tests. It will be recalibrated to verify the vendor's claim of a repeatability of 0.02°F throughout the range of -400 to -425°F.

E. THRUST CHAMBER CONTROL TEMPERATURE TRANSDUCER DEVELOPMENT

Discussions were held with Rosemont Engineering Company centering around ways to overcome time response, shunt leakage, and repeatability problems; and for ways to facilitate filling thrust chamber resistance thermometer transducers with an inert atmosphere. All of the three apparently promising designs overcome the shunt leakage problem by dropping the resistance and thus lowering the sensitivity of the transducer. To further reduce leakage one end of the coil would also be grounded to the sheath. In two cases the problem of slow-response time was approached by placing the sensory element where it could be heated directly by radiation. The amount of beryllia to be heated was also minimized in some cases. Analytical and analog studies will be required to determine how effective these changes may be for speeding up response time. The repeatability problem was attacked by removing the possibility of shorting between coil loops, and by improving the contained atmosphere.

F. THRUST CHAMBER CONTROL PRESSURE TRANSDUCER DEVELOPMENT

Fabrication of a pressure transducer fixture was completed. The fixture will provide mounting accommodations for eight potentiometer-type pressure transducers (four servonic and four Giannini) and will cyclically pressurize them in 5-incremental steps, from 0 to 750 psia.

Irradiation testing is scheduled for 29 July 1963.

G. REACTOR NUCLEAR INSTRUMENTATION

There was no significant activity on this project during the period.

H. REACTOR NON-NUCLEAR INSTRUMENTATION LABORATORY TEST PROGRAM

High temperature tests in a combined hydrogen and graphite environment were conducted on seventeen tungsten/tungsten, 26% rhenium, thermocouples. Two thermocouples failed at approximately 4200°R. The others failed at temperatures ranging from 4340°R to 4641°R, due to melting of the sheaths.

During testing, the following previously unreported phenomenon was observed: Over a 5-minute period, with the temperature held at 3960°R, the emf of the thermocouples decreased. On lowering the temperature of the oven to 3660°R, the emf readings indicated 300°R lower than had been the case when the same temperature had been achieved prior to reaching the highest temperature. Further experiments are planned to ascertain the cause. Performance of the thermocouples was comparable with the optical pyrometer up to the observed degradation.

Moisture sealant tests for sheathed thermocouples were performed as follows: The ends of the stainless-steel sheathed MgO insulated thermocouples were sheared and then sealed, using an epoxy (EPY 400) and an inorganic moisture sealant, (Aeroseal, an Aerojet product). The thermocouples were then immersed in water.

Before treating 16 sample transducers, insulation resistance for both substances ranged from 4000 megohms up. After 176 hours in water, the lowest value was 40 megohms. Most resistance ranged from 140 megohms to greater than 5,000 megohms. The two proposed compounds will be irradiation tested in the next tests at GTR-Plum Brook.

Vibration testing was conducted on ten exposed junction copper constantan T/C's (0.040-in.-OD, 5.5-sheath MgO insulation), for one hour each test under the following conditions:

Acceleration	Frequency
10g	30 cycles
12g	120 cycles
8g	600 cycles
8g	1200 cycles

No ill effect was detected in either wire or insulation resistance.

A second test was conducted on the same group of thermocouples. It extended over a four-hour period, at a 10g level, 30 cps, with vibration amplitude of ±0.009-ib. One thermocouple failed after two hours as a result of an open junction. The remaining thermocouples were still intact at the end of the four hours. Vibration tests will be repeated to determine the cause of any induced, spurious signals.

Tests were performed to determine the effects of cryogenic temperatures on the operation of displacement transducers. Six Schaevitz units, four Physical Science units, and eight Crescent units were tested for the following characteristics: linearity, sensitivity, primary and secondary impedances, null voltage, and insulation resistance. Records were also made of the effect on these characteristics with ferrite material surrounding the transducer.

Based on the results of this testing, Crescent Models 100-3K-1S and 250-3K-2S were recommended for application on NRX-A1. The Physical Science units successfully passed the tests, but were rejected because of their large physical size. The Schaevitz units failed the test for sensitivity as a function of temperature. The vendor indicated that an improved model using wire with better temperature coefficient can be provided. This revised model will be tested when available.

Tests of apparent strain as a function of temperature were completed for NRX-A1 gages on graphite, aluminum, inconel, beryllium, and stainless steel; but have not yet been conducted for titanium.

By properly matching strain gages to materials, the following results were obtained over the temperature range from 75°R to temperatures of LN_2:

Material	Strain Gage	Maximum Strain Indication (Apparent Strain μ in./in.)
Aluminum Type 2219	C15-624	-1150 μ in./in. LN_2 temp.
Beryllium	C9-624	-550 μ in./in. LN_2 temp.
Inconel	C12-624	+625 μ in./in. -165°F temp.
Stainless Type 304	C12-624	+250 μ in./in. -90°F temp. -375 μ in./in. LN_2 temp.
Graphite	C6-624	+700 μ in./in. -165°F temp.

All gages used in the above test were Budd Company, Karma Alloy type, bonded with Eastmen 910 cement and coated with Gage Cote No. 2 and No. 1.

The test data indicated that temperature effects are not appreciable. The worst results were with aluminum over the temperature range 75°F to LN_2, where an apparent strain of 3 μ in./in.°R was observed. Investigation is currently underway to improve this effect by using a gage having an expansion coefficient more nearly that of the aluminum Type 2219.

Work is progressing in the area of radiation effects on strain gages. Compensation techniques are being investigated, and the dummy gage technique appears the most promising at this time.

The eddy current probe for rapid detection of fuel-element fractures was fabricated into a prototype unit.

J. RADIATION EFFECTS TEST PROGRAM

1. Plum Brook Test Facility

Final test plans for irradiation tests of strain gages, resistance thermometers, thermocouples, pressure transducers, and displacement transducers were issued.

The majority of the test fixtures and test equipment are on hand. The remainder is being fabricated or procured, and is presently on schedule.

2. General Dynamics Ground Test Reactor

The post-irradiation examination was completed for transducers tested in the May tests. Data are now complete, and work has been initiated, on the final test reports.

Final assembly of GTR fixtures for the August test was completed. All equipment has been delivered or is awaiting delivery to General Dynamics. The August test will include strain gages, displacement gages, pressure transducers, thermocouples, and resistance temperature detectors in a LN_2 environment.

K. BENDIX SUBCONTRACT

Two reports were issued by Bendix during the month of June:

Noise Considerations in NERVA Diagnostic Instrumentation, by T. A. Somer, Bendix Report 2333, and Optimum Frequency for Variable Inductance Transducers for the NERVA Environment, by T. J. Mohan, Bendix Report 2345.

Bendix representatives are continuing their investigations and analysis of various NERVA instrumentation problems.

L. SURFACE MOUNTING OF TRANSDUCERS

Using the Rockide process, a specially designed, 2000-ohm, strippable-type, strain gage was mounted on a 17-7 pH steel beam. Output signals of + 1 volt and - 1 volt were obtained at beam deflections of ±3000 μ in./in. μ. Additional studies of high output systems are being planned.

On 13 May 1963, a test of 74 strain gages was performed at GTR. Conclusive radiation effects data obtained has not, as yet, been released.

M. ENGINE INSTRUMENTATION EVALUATION

Environmental test specifications were prepared for the testing of the NRX-A1 Engine instrumentation. Based on these specifications, proposals were received from two independent environmental testing laboratories. After review, both firms were found to be capable of performing the required tests, commensurate with schedule requirements.

A concept was evaluated for a cryostat to provide precise calibrations of temperature transducers in the liquid hydrogen temperature region. The primary design consideration was the achievement of stable temperature gradients by use of a central core of solid aluminum as thermal moderator. Use of the same cryostat for calibration of pressure transducers is considered to be entirely feasible.

Shielding calculations were performed for a typical piezoelectric accelerometer mounted in the NERVA environment. Calculations indicated that, with minimal shielding, the useful life of the crystal could be extended to encompass the anticipated NERVA radiation doses.

Evaluation vibration tests performed on two Statham PA 732 TC pressure transducers to provide backup environmental data for similar units being used on the NRX-A1 engine. The test data indicated that these units were suitable for use on the engine.

Item 2.5 FIELD SUPPORT (RIFT)

General exchange of engineering information and liaison activities continued throughout the month.

Details of activities are reported under individual task items concerned.

Item 2.6 **RELIABILITY AND QUALITY ASSURANCE**

Test specifications for the component test program were reviewed by WANL, and are being incorporated into the program revisions. WANL reviewed and signed off 57 final drawings. Six instrumentation layout drawings were reviewed, and recommendations were made to improve their reliability.

Preparations and procedures for the reactor shipping test were reviewed by WANL. Corrective actions were initiated and followed-up to ensure a high probability of obtaining the desired test data.

WANL quality-control representatives completed thirteen surveys of suppliers, resulting in 8 approvals, 4 conditional approvals, and one disapproval. In addition, WANL Quality Engineering contributed to the writing of 52 reactor-assembly process-outlines.

LRP completed a review of data from the first test of the hot-gas drive of the Mark III, Mod. III, turbopump assembly. Review of test data has been started for the second test in the series of hot-gas drive tests of this item. Results of reliability review of data from this test, and subsequent tests in this series, will be consolidated in a single report at the end of the test series.

Four Engineering and Reliability Evaluation Board Meetings were held to consider reliability recommendations resulting from LRP's design reviews, test plan evaluations, and test data reviews.

Reorganization within the Liquid Rocket Plant continued during the reporting period. Organization of the Quality Control and Reliability Senior Division has not been fully completed.

The LRP Quality-Control Division conducted 22 vendor evaluations and, in addition, completed 4 internal Quality Control audits.

Reliability monitoring by Bendix resulted in further investigation of clearance and dimensional checks on the NT-B4 and NT-C1 transmissions of the TPCV. The results of this investigation indicated that clearances provided by minimum and maximum dimensional buildup were adequate and that no problem existed.

Design review effort by AMF was conducted on the ETV superstructure, outboard jacks, inching drive, azimuth drive, fore and aft and lateral drives, stop mechanism, counterweight, MCC fire control system, OPS plumbness indicator, bridge, and trolley.

The REON Reliability Department reviewed a tentative test plan involving sensitivity testing of irradiated explosives. Consultation was provided for Westinghouse and REON engineering on a problem concerning the reliability of test instrumentation to be used on NERVA engine tests.

The REON Quality Assurance Department has prepared an NRDS Quality Assurance Program Plan. A review copy of the plan will be distributed to solicit details for completion of the manual, and to obtain comments prior to establishing its final concept. In addition, the end-item test plan for the NRX-A1 Assembly was developed, and will be completed when all of the end-item test and inspection procedures are reviewed, and final approval is obtained from SNPO-C. LRP and WANL are currently in the process of developing applicable end-item test and inspection procedures to meet established delivery dates for the end items.

Monitoring of Reliability and Quality Assurance activities at the participating plants was conducted on a continuous basis of the REON Product Assurance Division. More detailed information concerning Reliability and Quality Assurance activities is reported in a separate document.

Item 2.7 SAFETY

A. NUCLEAR ACCIDENT ANALYSIS AND SAFEGUARDS SUMMARY REPORT

The reactor description for the hazard report is being updated to incorporate changes in mechanical design and to discuss the corrosion resistance of the fuel elements to high-temperature hydrogen. Results of thermal analysis and Test Cell A control-system design were reviewed for use in the report.

An effort was initiated during this period to assess the radiological consequences downwind of fission products released during normal operations or following a nuclear excursion at NRDS. Particular emphasis is being placed on the correlation of predicted contamination with the results of measurements made during the Kiwi-A series of reactor tests. For doses within a few miles of the test cell, the most significant parameter other than atmospheric conditions, appears to be the effective height of release of the activity and the nature of the release model.

A comparison of the analytical methods used by WANL to determine the multiplication constant for fuel assemblies and geometries which occur in fuel production and handling was initiated.

A review of safeguards against accidental criticality in the WANL reactor assembly area is in final preparation.

Testing was initiated on the in-flight poison system mockup. Tests were conducted using both teflon coated, 0.047-in. stainless steel wire, and uncoated 0.063-in.-stainless steel wire. In these tests, velocity is maintained constant, and data are being collected relating radial wire position as a function of pull force and whipping effect. It was observed that, when removing wires from the outermost radius of the core, the uncoated wires eroded the coating off the elements, while the coated wires did not cause visible damage.

B. FISSION PRODUCT DIFFUSION STUDIES

Post-irradiation heat treatment of WANL-FP-2 samples (oxide fuel) has been completed. The percentage of gross activity lost as a function of time, temperature and environment are given in the following table.

Sample No.	Temp (°C)	Pressure (mm)	Time (Min)	Percent Activity Loss
1	1600	10^{-4}	30	31.6
2	1600	10^{-4}	15	19.0
3	1600	760*	15	9.8
4	1400	10^{-}	5	1.4
5	1400	10^{-4}	15	2.8
6	1400	10^{-4}	30	6.5
7	1400	10^{-4}	60	10.8
8	2000	10^{-4}	15	32.4
9	2000	10^{-4}	60	39.5

Radiochemical analyses of these samples is in progress, and will be reported as part of the final capsule report.

Irradiation capsule WANL-FP-3, irradiated May 17, 1963, has been opened at WTR. Radiation level, sample weight, and sample dimension measurements are now being made in the hot cell facility.

WANL-FP-4 and WANL-FP-4A capsules have been shipped to GETR for irradiation. The latter capsule contains samples for simulated re-entry tests.

Low-level irradiations at WREC and post irradiation heatings at WANL have been performed on irradiations samples FP-B and FP-C. Enriched fuel is now being used in the low-level irradiation studies.

The literature search on the Fission Product Inventory Code has been completed and a set of nuclear constants have been agreed upon with NRDL. A new computer code is being written to determine fission product inventory and activity for NERVA operations. The essential features of the code are:

1. Five hundred individual isotopes are being included in the program.
2. Multiple periods of reactor operation at constant power and periods of decay can be considered.
3. Loss of isotopes is limited to radioactive decay. Transmutation by neutron absorption is not included.
4. The output of the code will give activity of the individual isotopes and several-energy-group gamma and beta decay powers.

*This run was made in a helium atmosphere.

The first section of the code which will compute the isotopes activity has been written and is in the de-bugging stage.

C. MECHANICAL AND PHYSICAL ASPECTS OF REACTOR EXCURSIONS

The analytical and experimental work on the hydrodynamics of the immersion of a NERVA core in water has been completed. A summary of this investigation follows:

The immersion of a core has been briefly described and two general types of flooding have been postulated: a gradual flooding and a hydrodynamic impact flooding. The basic objective of this program was to predict the density and relative flooding rate of water into a NERVA core for each of these types.

The theoretical analyses which were performed included the calculation of the terminal free-fall velocity of a NERVA core, a qualitative description of the phenomena during hydrodynamic impact flooding, an approximate prediction of the initial rise rate of water into the core after impact, and the determination of the low-velocity transient potential flow into the core coolant channels during gradual flooding. Two basic models were used in the experimental program: drilled cylinders and solid cylinders. The hydrodynamic impact tests on drilled cylinders permitted the evaluation of the relative flooding rates of water into the models, whereas the tests on solid cylinders yielded the magnitude of the potential flow theory pressures at the base of the models during deceleration. These experimental results were correlated with the theoretical analyses.

The initial rise rate of water into a NERVA core during hydrodynamic impact was predicted from the empirical equation as functions of impact velocity and orientation angle. Expressions for the maximum and average densities of water in the core coolant channels during this type of impact were developed. The approximate depth of a NERVA core below the surface of water as a function of impact velocity and time was determined from the hydrodynamic impact experiments on solid cylinders. The transient analysis of a low-velocity potential flow into a core during gradual flooding has been applied to NERVA for several fixed depths of immersion.

The following sub-routines have been written for inclusion in the RAC Code:

LOTMP: Handles delayed neutron kinetics for low temperature region (to 313°K).

HITMP: Handles the delayed neutron kinetics at high temperatures.

SCRAM: Permits representation of control drum scram after a given core power level is reached.

These sub-routines have been compiled individually. Modifications are being made in RAC which will provide consistency between the main program and the various sub-routines.

Two sets of experiments were shipped to TREAT. Four specimens were used to check out a new photographic capsule design and to acquire refined data on the threshold energy required to cause damage to lined fuel material. Three other specimens which had been pretreated with fluorine have been pulsed at different levels to determine the effect of the fluorine pretreatment on the damage threshold. The results of these tests are not yet available.

The electrical transient experiments have been continued to achieve meaningful temperature readings. Through tests it was determined that it was possible to achieve massive fragmentation of a sample with an energy input of 7.7 Kw sec/g. Since successively lower energy inputs did not result in vaporization, it appears that bracketing of the critical vaporization energy threshold will be feasible within the limits of the test equipment employed.

D. RE-ENTRY SAFETY STUDIES, RESEARCH AND DEVELOPMENT

Re-entry tests have been completed in the regime which is reaction-rate controlled and in the transition flow regime. Mass loss rate data for hemispherical samples in the reaction rate controlled regime have been compiled. Rate data for the transition flow regime are currently being analyzed.

A test employing potassium vapor over a three-hour period with Type 11 fuel did not result in proper destruct.

Four tests were run on 9-inch, 100-gram specimens of Type 111 fuel, employing 40 grams of chlorine tri-fluoride in each test. The tests were run for 1 hour at about 240°C under vacuum conditions. It was not possible to

duplicate the results of a previous test where a 2.6-gram specimen was employed, as the channels became clogged and reagent flow leaked around the specimen. Specimen weight losses ranged from 0 to 24%.

A summary screening report on chemical destruct systems has been completed, and issued in draft form.

E. STUDY OF FUEL ADDITIVES FOR ENHANCEMENT OF FLIGHT SAFETY

The preliminary feasibility report on the use of additives has been completed in final form (WANL-TNR-114). Four additives were selected from the initial screening tests as exhibiting the most promising combination of oxidation enhancement and mechanical properties under simulated re-entry conditions. These additives are rhenium metal, tungsten carbide, molybdenum carbide, and vanadium carbide.

Preliminary results on the most recent dynamic oxidation tests for fueled graphite, sensitized fuel graphite, and sensitized 5 w/o Mo_2C are shown below:

Material	Temp (°C)	Pressure (mm)	dn/dt (atoms/cm^{2}min) x 10^{19}	Percent Weight Loss in 10 min
*Reference (fueled)	1200	0.1	4.82	8.4
*Reference (fueled)	1000	0.1	0.72	1.33
**Reference (fueled)	1200	0.1	4.73	8.1
**Reference (fueled)	1000	0.1	1.43	1.91
*Reference (fueled)	900	0.1	0.89	1.65
**5 w/o Mo_2C	1200	0.1	6.88	18.4
**5 w/o Mo_2C	1000	0.1	4.82	7.86
**5 w/o Mo_2C	1200	0.4	10.1	26.0
**5 w/o Mo_2C	1000	0.4	9.28	14.54

*Fired at 1900°C.

**Sensitized at 2750°C.

In addition to the oxidation runs, the specimens in this series of tests are being analyzed by spectrographic techniques to determine loss of additive material due to oxidation. The specimens are also being gamma counted to follow uranium loss. No activity loss was found for any of the above specimens, indicating that there was no weight loss of uranium during the test.

Spectrographic analyses of the additive material have not yet been obtained. However, two effects are evident: an increase in pressure causes an increase in the oxidation rate, and the decrease in the oxidation rate with temperature is less for the Mo_2C-bearing specimens than for the fueled graphite specimens. The latter effect suggests the possibility that additives may sustain the oxidation rate at lower temperatures for longer times, which would be of importance in re-entry ablation.

Item 2.8 TRAINING

The Test Cell A indoctrination course was presented for the first time as a pilot run to ten enrollees during the week of 3 June 1963. Participation in this course was limited to NERVA engineers assigned to TC-A and to training personnel. NERVA engineers at TC-A have been assigned to LASL's systems engineers for training.

Study guides, visual aids, and instructor lesson plans in rough tentative form were used during this presentation. However, experience with the first two presentations of this course dictate the advisability of revising and improving these documents and materials. The materials in final form are, therefore, rescheduled for completion by 23 August 1963. The second presentation of the course is scheduled to begin 15 July 1963, to satisfy the requirements of new personnel.

Work on the preparation of an itemized, specific, training plan for contract year 1963-1964 was begun. This plan will reflect the latest redirected NRX effort; completion of the plan is scheduled for September 1963.

A meeting was held on 24 June 1963 with Mr. E. Burciaga of NASA Western Operations Office to critique the Test Cell "A" course and to discuss the training program in general.

Item 2.9 LASL SUPPORT

Thirty-six technical personnel are currently assigned to LASL support activities.

DECLASSIFIED

SECTION III (cont.)

TECHNICAL DISCUSSION

TASK 3.0 MDS SUPPORT

DECLASSIFIED

Item 3.0 GENERAL SUPPORT FACILITIES

REON Report 2578 - Program Requirements Document for MRDS - was submitted, and is to serve as a basis for revision due to programming changes. Unless otherwise instructed by SNPO-C, quarterly revisions to the PRD will be submitted on format and in conformance with the ground rules used in the preparation of the initial PRD.

Review was accomplished for the Final Status Report prepared by the Ralph M. Parsons Company on the Preliminary Master Plan for MRDS under contract with SNPO-N.

Item 3.1 NERVA EXHAUST SYSTEM (NES)

A. SCALE MODEL DEVELOPMENT

1. Sub-Subtask 3.1.2, Scale Model R & D Program

During this report period, testing was initiated to determine the pumping capabilities of two secondary ejector nozzles in conjunction with the ejector (SST-2f) to be used in ETS-1 and for possible use in ETS-2.

Work is continuing on the problem of supersonic gas mixing at Dynamic Sciences Corporation. Equations have been derived for the mixed flow region and are being reviewed.

2. Sub-Subtask 3.1.3, ETS-1 NES Configuration

Leakage tests of the SST-2 configuration continued during this report period. No improvement in leakage capability was obtained when the turbine exhaust gases were introduced through two sonic nozzles located at the NERVA nozzle exit plane. Expansion sections were then added to the turbine exhaust nozzles and a marked improvement in the leakage capabilities was obtained. The NERVA nozzle and the turbine exhaust flow rate were then set at their design flow rates, and fluid was introduced into the engine compartment to simulate leakage from the seals. The preliminary data indicate that the NERVA nozzle will flow full when the turbine exhaust gases are introduced supersonically at the nozzle exit plane, and when one pound per second of nitrogen leakage from the seals enters the engine compartment. During the next report period, two other methods to increase the leakage capability will be tested. This sub-subtask (3.1.3) will be completed 15 July 1963.

B. SUB-SUBTASK 3.1.4, DESIGN OF ETS-1 DUCT

The preliminary design of the ETS-1 duct was continued during this report period in the following major areas:

1. Sub-Scale Structural Testing

The fabrication of the sub-scale structural rectangular coolant passage test specimen, as awarded to Cromer Mfg. Co., was completed, received, and inspected during this report period.

The request for sole-source testing of the structural specimens to be awarded Space General Corporation is pending approval by SNPO-C.

The circular coolant passage sub-scale structural testing program has been outlined, and is presently under evaluation.

2. Sub-Scale Seal Testing

Additional sub-scale seal testing was conducted during this report period. A vibration test was performed which subjected the double seal, seal flange coupling, and support fixture to vibration loads.

Continuous monitoring of the gas leakage was obtained throughout this series of tests with the result that no appreciable leakage was detected for the Conoseal gaskets.

Further load induction tests will be performed in order to establish and verify gasket configuration.

3. Preliminary Design

Design work during the past month has concentrated on the primary and elbow portions of the duct. Preliminary design drawings prepared reflecting this effort are tabulated below:

ETS-1 NES Duct Final Assembly
Primary Duct Assembly
Severance Plane - Primary Duct
Seal Area - Primary Duct
Upper Primary Duct Support
Truss-Duct Support Assembly
Lower Primary Duct Support

4. Dynamics Analysis

Approval has been requested of SNPO for awarding of a contract for the dynamics analysis program to the Dynamics Science Corporation as a sole-source item.

5. Coolant Flow Analysis

A study was conducted to establish the water demands of the complete ETS-1 process-water system. This system included assumptions of

pressure drop that may be present in the final truss-coolant supply network, as well as pressure drop as a function of the duct demand flow rate which will establish the coolant flow system limitations. Present stress study indicates that the truss-coolant supply network is not stress limited and will be primarily sized by the water demands.

This initial study finding concluded that the NES duct can be adequately cooled with the present existing process system.

A continuing flow-balance study will be made as the system water demands are finalized.

6. Stress

An evaluation of the tubular coolant channel configuration was conducted during this report period. This evaluation included a review of SNPO-C's elastic-plastic analytical study which substantiated the REON cyclic life analysis predicting approximately ten engine firings.

A preliminary load and structural analysis was conducted for the duct coolant channels specifying thickness, material, and geometry for both the tubular and rectangular configurations. Additional effort is being expended to optimize the analysis and hence obtain the maximum operational cyclic life.

C. SUB-SUBTASK 3.1.5, AUXILIARY GENERATORS

1. Steam Generator System

Cost quotations for the ETS-1 steam generator system were received from two of the three bidders - The Marquardt Corporation and Thiokol Chemical Corporation. The proposals submitted by these two companies were reviewed and an evaluation procedure was established and initiated during the report period. As part of the evaluation, visits were made to each company to inspect fabrication and test facilities and to discuss the submitted proposals in detail. The evaluation will be completed early in the next report period and the choice made from a technical standpoint of the supplier for the steam generator hardware.

The steam generator system will be installed at ETS-1 on the vertical wall on the front of the stand adjacent to the pipe chase; this choice is concurred in by SNPO-C. A list of facility modifications required immediately in order to conduct steam-generator system development testing during CY 1964 was presented to the customer. These modifications are partially contingent upon the selection of the steam generator supplier.

The trailers which had been allocated for the development instrumentation and control system for the SGS from Norton Air Force Base, California, have been removed from the list of available equipment. Therefore, new allocations have been made from equipment presently located in the United Kingdom. It is anticipated that delivery of the trailers will be made during the month of August.

2. ETS-1 Water System Testing

The test program plan originally established for conduct of the water system flow test was disapproved by SNPO-C, and copies of a revised plan have been submitted for approval. This plan reduces the magnitude of the program without loss of the major goals - determination of flow distribution and system pressures available to the Steam Generator System and the NERVA Exhaust Duct.

D. SUB-SUBTASK 3.1.7, NES INTEGRATION

1. Duct Installation and Removal Criteria

During this report period, preliminary studies were made of the various operations and methods involved in the installation and removal of the NERVA Exhaust Duct in ETS-1. These have included decontamination problems and the disposition of the duct after removal from the test stand.

From these studies, a list of Ground Rules were formulated to assist the selection of GSE and facilities equipment, and to aid the operational planning involved in duct installation and removal from the test stand vault.

2. Duct Decontamination

A program plan was established for the CY 1963 effort in which a number of tests were outlined.

There are a number of problem areas that require additional study. Although some of these areas do not relate directly to decontamination, they are indirectly related, and a firm plan of study is desired. The particular items referred to are:

The effect of hypersonic core particles on the inner duct walls.

Emergency removal of water from the duct as a result of abnormal firing.

Another area of study involves the angle of the exhaust exit. Flame characteristics, solid particle dispersion, and site erosion also require attention.

Although the main concern is that of decontamination, those areas that might influence the overall design of the duct are receiving prompt attention (for example, hypersonic core particles ejected from the engine).

An accurate estimation of the plate-out condition in the duct is the prime objective of the proposed testing program. Knowledge of such items as listed below is important in formulating an adequate decontamination program: fission products and the quantities of each, the state of deposition, the radiation level percentage of residual radiation to contaminant radiation.

Most of the significant items affecting decontamination have been noted and those necessitating future intensive study or analysis have been singled out for immediate attention.

Item 3.2 TEST STAND

REON Report 2506, Mandatory Facility Additions, Engine Test Stand No. 1 at NRDS and Addendum, ETS-1 Fluid Requirements was completed and distributed.

NERVA Design Criteria, NDC-65, Penetrations, Top Shield, ETS-1 Engine Compartment was concluded and approved.

Specifications and drawings for the ETS-1 fire protection system, and for facility additions and modifications were reviewed and comments were prepared.

Data on the PERT system for ETS-1 were received from SNPO and reviewed. Comments are being prepared in parallel to the establishment of a bi-weekly report system.

A review of process water system flow tests proposed by NTO was conducted.

ETS-1 Run Tank Topping Studies were completed and reported.

Efforts to establish and upgrade ETS-1 Facility Functional Requirements, consistent with engine design and program requirements, were continued as follows:

A. Definition of the Engine-to-Facility Interface. Review and revision was continued for the engine adapter design criteria, and the miscellaneous auxiliary control system requirements.

B. Evaluation of wave phenomena in the emergency cool-down and similar systems was conducted.

C. Review and updating of existing design criteria was performed to further define ETS-1 functions.

D. Review and revision of PERT and manpower requirements was held, to assure that they are appropriate for the steam-generator system and "tin can" duct tests.

E. Revision and expansion of ETS-1 operating procedures and count-down schedule.

F. A review was made of Cold-Flow Test System propellant supply line, for possible integration into ETS-1.

Item 3.3 ETS-1 INSTRUMENTATION AND CONTROLS

A. GENERAL

REON is currently reviewing the ETS-1 I&C System "Design Package" submitted by EG&G. This package represents the complete system and subsystem scope definition in terms of operational, functional, and safety requirements, and will provide all engineering information necessary for selection of referral items, if required, due to funding constraints. REON review disclosed that the package was not complete and EG&G and SNPO were so notified. When the package has been approved, it will be defined as the I&C System and Subsystem Design Freeze REON review comments are scheduled to be presented to SNPO-C on 8 and 9 July 1965 at REON/Azusa.

This package consists of

240 "F" size drawings
Design Data - 6 volumes
Miscellaneous Exhibits:
31 Specifications
T.V. Camera Motion System RFP 1183-10E
2 drawings

The ETS-1 Diesel Generator test specification has been prepared by REON and submitted to SNPO-C for approval and has been subsequently approved. REON will direct AGC personnel making the diesel generator tests.

The current requirements for the Meteorological System have been submitted to SNPO-C for concurrence prior to submittal to EG&G as technical direction.

Addendum No. 8 to the ETS-1 I&C Criteria, Duct and Shield Monitors has been prepared and submitted to SNPO-C for concurrence prior to submittal to EG&G as technical.

The Design Criterial for the emergency-coolant-flow-measurement pipe spool has been revised and re-submitted to SNPO-C as Revision "A". SNPO-C

concurrence was received, and the criteria was subsequently transmitted to EG&G as technical direction.

REON has reviewed the common-excitation power-supply scheme as proposed by EG&G. REON presented technical data supporting their proposal for single-channel excitation-power Supplies to SNPO-C on 14 June. SNPO-C subsequently concurred with the REON proposal

Work is in process, and will continue, in the following areas:

1. Resolve drawing title blocks with SNPO-C.

2. Review was submitted to SNPO-C of EG&G recommendations, and REON's subsequent recommended alternate approach, concerning the ETS-1 meteorological subsystem designs. This item cannot be completed, pending approval from SNPO-C.

3. Review integration of GSE (Engine Simulator and Checkout).

4. Review Facility Modification Design Data File (Rev. B.), and Facility Modification Test Stand Terminal Boxes (sheet 5 of 10) (Rev. A.)

5. Review EG&G Television Camera Motion System, RFP 1183-10B. Package includes Mechanical Equipment Reliability Design Standards; Attachment A (BF 4509), drawings BB-4560, BC-5321, BE-1624, BF-1625, BE-1786, and BE-1799.

6. Review SNPO-C comments on ETS-1 I&C Design Criteria Addenda 4, 5, and 6.

B. REVIEW OF DOCUMENTATION

1. Review of EG&G Documentation, Design Phase

Approximately 95% of the "Design Package" submitted by EG&G has been reviewed and comments have been prepared.

2. Review of EG&G Documentation, Functional Specifications, Detailed Preliminary Design Documents, Standard/Special Functional Family Trees.

Approximately 90% of these documents have been reviewed and

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commented upon. The remaining 10% have either not been submitted, or are currently being reviewed as part of the "Design Package."

C. GENERAL REVIEW AND CLARIFICATIONS

Detailed review and clarifications were made by REON, with subsequent transmittal to EG&G, of the following:

1. Television System

REON notified EG&G that the T.V. Motion System, RFP-1183-10B, had not been submitted for review prior to transmittal to bidders. These data are currently being reviewed, as a miscellaneous exhibit of the Design Package.

2. TC&P System

REON defined the steam generator and duct cabling requirements of 14 February and reconfirmed by TWX on 4 June. The terminal boxes for this cabling cannot be defined pending direction from SNPO-C.

REON defined the EC and REC requirements page 165 of the overall preliminary design package.

3. Control Point Building I&C Equipment Proposed Layout

REON revised drawing ICC-204C, sheet 1 of 6 and submitted ICC-204D. EG&G was directed to utilize this drawing which supersedes all previous direction in the system design.

4. Facility Modifications, Test Stand Terminal Boxes

EG&G was directed by REON to display the remote-purge loss indication on the safety graphic panel in the Control Room.

5. Equipment Rack Layouts

REON defined the latest requirements for equipment rack locations and scheduled a joint review during reviews of the Design Package.

6. Signal Conditioning Requirements

REON directed EG&G to modify affected designs to provide for

individual excitation power supplies instead of common excitation power supplies as proposed by EG&G.

REON defined requirements for temperature transducers; including zero offset and standard ranges for RTT channels.

D. SYSTEMS COORDINATION

REON personnel were active during this reporting period in the following technical coordination, design review, and liaison meetings:

1. 31 May (not covered in May Report)

REON personnel participated in a field survey of locations for oxygen and combustible gas sensors at NRDS with REON Test Operations and EG&G personnel. Definition of locations resulted from this survey.

2. 5 and 6 June

REON personnel attended the Facility Modifications Initial Design Review meetings, covering cable trays and test stand terminal boxes, at EG&G/Las Vegas. REON comments presented at these reviews will be incorporated in final design data to be presented at a later date.

3. 6 and 7 June

REON personnel attended a design-review meeting at EG&G/Boston relative to equipment rack space allocation and power supplies. Conclusions reached included the relocation of racks from the CPB to the FCR and the addition of racks for the REC system.

4. 10 June

REON personnel visited SNPC-C relative to evaluation of Data Reduction equipment. It was concluded at this meeting that EG&G should furnish the further evaluation of three recommended machines.

5. 14 June

REON personnel participated in technical discussions at SNPO-C relative to individual excitation power supplies as proposed by REON in comparison

with common excitation power supplies as proposed by EG&G. SNPO-C concurrence with the REON proposed scheme resulted in appropriate direction to EG&G. This meeting was designated I&C Meeting No. 11. Comments and agreements were documented in minutes of meeting prepared by EG&G.

6. 13 June

REON personnel visited Packard-Bell, Santa Monica and Anaheim, to evaluate the Model-440 Data Processor.

7. 17 and 18 June

REON personnel visited NRDS to coordinate the test equipment required for the ETS-1 Diesel Generator tests.

8. 19 June

REON personnel attended technical conferences with EG&G personnel at REON/Azusa to review signal conditioning requirements. Technical requirements were reached and documented.

9. 20 June

REON Personnel participated in a field survey of the TV and photo station locations at NRDS. Station locations are defined.

10. 21 June

REON personnel participated in the initial design review meeting, covering facility modifications and building modifications with EG&G personnel at EG&G/Las Vegas. Comments and agreements were documented in minutes of the meeting taken by EG&G.

11. 21, 24, 25, 26 June

REON personnel attended the ETS-1 I&C System Design Presentation given by EG&G at SNPO-C as observers. This meeting was designated as I&C meeting No. 13. Minutes of meeting were prepared by EG&G.

12. 24 June

REON personnel attended a technical meeting at SNPO-C with EG&G personnel relative to the Data Processing requirements. Comments and agreements were documented in minutes of meeting taken by EG&G.

13. 27 June

REON I&C group attended a presentation of the present I&C System design concept at REON Azusa. In attendance were personnel from the Engine Design group, SNPO-C engine personnel, REON Test Operations, NES Design and Engine Controls, and LFP-Sacto.

14. 19 and 20 June

REON personnel attended I&C Meeting No. 12 at REON/Azusa with WANL and EG&G personnel. Purpose was review of the signal-conditioning requirements. Agreements and comments were documented by minutes of meeting taken by EG&G.

Item 3.4 TEST STAND

The Engine Development and Facilities Support Programs are being continually monitored to disclose any changes that may affect the ETS-2 design and completion schedule.

A SNPO REON meeting was held on 26 June to discuss revisions to the ETS-2 Criteria Report (REON Report 2502). Revision agreements were reached and a dead-line of 15 July was fixed for publication and delivery to SNPO of the revised report.

A PERT Network of ETS-2 engineering and construction issued by SNPO-C (CatCo) has been received by REON. The decision to use a 25:1 NES for ETS-2 will necessitate some modification of the network.

Item 3.5 E-MAD BUILDING

A. OPERATIONAL REQUIREMENTS

NERVA Operational Requirements were expanded, updated, and clarified to assist the A&E in upgrading design criteria, and in formulating final designs for the following:

1. Post-Operative Area Door Interlock System for control and safe operations, transmitted 27 June.

2. Materials Logistics and System Conceptual Study for transfer between post-operative cells 165 and 166; to establish definite dimensions for the construction provisions of the system transmitted by TWX Message No. 918, dated 24 June.

3. E-MAD Radiation Monitoring System, Phase I and Phase II, transmitted 17 June.

4. Preliminary Outline for Shielding Integrity Check on E-MAD, transmitted as 17 June.

5. Feasibility studies of E-MAD to accommodate NRX. These are being accomplished in three phases: Phase I Study was transmitted 4 June; Phase II Study was transmitted 25 June; and Phase III Study Preliminary Data was transmitted 12 July.

NERVA Operational Requirements currently under study are:

1. Phase III of Feasibility Study for E-MAD Facilities and railroad spur to accommodate NRX. This study will define additional facility and equipment required to accommodate, concurrently, E-Engine and NRX Operations in the E-MAD Complex.

2. Plots of the viewing volumes for 38 windows, as opposed to 48 windows, of the E-MAD Phase I. The data include conclusions relative to the operability of the E-MAD Complex with only 38 of the possible 48 windows installed at time of beneficial occupancy, as requested on 13 June.

B. DESIGN REVIEW

In accordance with SNPO-C Procedure for Approval and Distribution of the Drawings and Specifications Prior to Award of Construction Contract, Revision III, dated 27 November 1962, all of the E-MAD Phase II (For Approval) Drawings and Specifications of the 200, 300, 400, and 700 Series were reviewed, and the comments transmitted by TWX to SNPO-C. "Y" Radiation Monitoring System Drawings (in the 100 series) are yet to be completed. Review is to be based on SNPO-C decisions at a Radiation Monitoring meeting to be scheduled by SNPO-C. Reviews were completed of 143 Phase II drawings, and transmitted to SNPO.

NERVA Operational, functional, and safety requirements were made definite, as required, in order to conduct a comprehensive review of E-MAD design. Specific items and areas expanded during this reporting period or which are now in preparation, or for which transmittals were made to SNPO-C, include: plug door special equipment (pass-thru) to provide transfer capability between Cells 165 and 166; continued development of a system concept of control; and segmented portions, etc., of the bus-rail system in the E-MAD Post-Operative area. The door-interlock system and material-transfer requirements for utilization of the south end of the E-MAD, were also firmly clarified, as directed and requested by SNPO-C.

A meeting was held with SNPO at Cleveland on 4 and 5 June to clarify SNPO-C actions or decisions relative to REON/WANL review comments on E-MAD Phase II drawings and specifications, and to delineate the requirements for a safety (audio-visual) alarm system for the south end of the E-MAD Building. Requirements for radiation-monitoring provisions in the E-MAD construction were also discussed.

A meeting was held with SNPO-C personnel at Cleveland on 28 June to discuss requirements and to define the following: E-MAD Post-Operative area door interlocks, material transfer, and the utilization of the south end of the building, as prepared and submitted to SNPO-C.

C. E-MAD ACTIVATION PLANNING AND PROCEDURE

Preparation and transmittal was continued on the following recommended equipment lists for E-MAD: rectilinear manipulator systems, general health and safety equipment, general purpose fire equipment, and master-slave manipulator equipment.

Preparation of the E-MAD Activation and Operations Planning Guide continued during this reporting period. The guide is about 20% complete for the E-MAD Phase I Cold-Bay Activation Section.

Review of E-MAD Phase II drawings and specifications continued. and pertinent comments were transmitted.

Work commenced on the feasibility study of the E-MAD building to accommodate an NRX reactor test program.

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Item 3.6 REACTOR DEVELOPMENT FACILITY

The LASL cold gas mixer was installed in the Test Stand at Test Cell A. Flow tests were conducted utilizing open-loop, or manual control, of the mixing process. The results of these tests indicated that, for the flow-rates and mixing ratios imposed, the mixing chamber was adequate and the system performed satisfactorily. More flow tests are scheduled for 24 July. Closed-loop, or automatic control, will be utilized for those tests.

Procurement was initiated for the additional 195 channels of wide-band signal conditioning data-acquisition equipment for Test Cell 'A'.

Six of the fifteen documents concerning Test Cell A Facility systems operations are being printed. Procedures for Control Point operations will be initiated in the near future in support of the operator training program to be conducted at the Reactor Development Facility.

Analysis continued on an emergency liquid cool-down system for Test Cell 'A'.

Work is continuing on documenting the As-Built conditions and capabilities of Test Cell A for NRX testing.

Further studies were continued on the translation of wide-band FM data to a form suitable for digital computer inputs. The LASL - EG&G preliminary design of the wide-band instrumentation was reviewed and is satisfactory. This work is now being coordinated by Test Site personnel, and bids for the wide-band equipment have been received by EG&G.

Item 3.7 RADIATION EFFECTS FACILITY (REF)

On 1 June, REON established, by TWX to SNPO-C, a target date of 12 June 1963 for transmittal of REON's Preliminary Data Requisition System Requirements for NARF.

On 5 June, REON established, by TWX to SNPO-C, a target date of 1 July for REON's PFS hardware interface drawing, and a similar data of 15 July for REON's instrumentation interface drawing.

REON was informed by SNPO-C of a proposed meeting to be held at SNPO-C 18-19 June to review and discuss M. W. Kellogg's conceptual flow diagram for NARF.

REON received from SNPO-C on 12 June a copy of M. W. Kellog's conceptual system flow diagram. This package was reviewed by REON and LRP, and a combined list of questions and comments was compiled.

On 14 June SNPO-C established with REON the agenda for the 18-19 June meetings. REON also asked for and received from SNPO-C, an extension of the submittal date for the Preliminary Data Acquisition System Requirements.

REON and LRP personnel attended the 18-19 June meetings at SNPO-C. As a result of these meetings, M. W. Kellogg was directed to proceed with a simpler process system. SNPO-C directed that the maximum run time for the NARF Facility be changed from 20 to 10 minutes, together with the relaxation of several facility operating requirements. REON was requested to comment concerning the effects of this redirection of the PFS test program.

In response to a SNPO-C request, Mr. McKeon of M. W. Kellog visited LRP on 26 June. During this visit, the ground rules for establishing the PFS hardware interfaces were established.

Item 3.8 NRDS RADIOACTIVE MATERIALS HANDLING, DECONTAMINATION, AND STORAGE COMPLEX

REON Report 2584, Operational Requirements for Radioactive Materials Handling, Decontamination, and Storage Complex at NRDS, was completed and submitted on 17 June. This report served as the basis for the design criteria for the task facilities.

The Minutes of the 28-29 May Technical Meeting, held in Azusa to review Task Programs, were submitted on 4 June; and the Approved Minutes were submitted on June 14.

Action-item-summary-reports were submitted to SNPO-C on 4 June and 20 June.

The design criteria for the Radioactive Materials Complex Facilities were completed in preliminary form and submitted, for approval to SNPO-C on 25 June. This satisfies the 1 July 1963 Milepost. The submittal consisted of the following documents:

REON Report 2592 - Radioactive Materials Handling, Decontamination and Storage Complex Design Concept and Criteria

REON Report 2592 Supplement - Detail Data for Cost Summary in Report 2592

REON Report 2603 - Engine Transport System Maintenance Building Design Criteria

REON Report 2603 Supplement - Detail Data for Cost Summary in Report 2603

REON Report 2592 presents preliminary design criteria with conceptual designs of the following facilities:

Decontamination Facility
Hot Engine Hold Facility
Warm Parts Storage Facility
(High Activity & Low Activity)
Spent Fuel Storage Facility
Radioactive Waste Disposal Facility (Burial)

Upgrading of the design criteria was initiated, and a meeting is planned in early July to review SNPO-C comments on the above documents.

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Item 3.9 RIFT STAGE DEVELOPMENT FACILITIES

There was no activity on this task item during this report period.

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SECTION III (cont.)

TECHNICAL DISCUSSION

TASK 4.0 PROGRAM MANAGEMENT

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Item 4.1 PROGRAM PLANNING AND CONTROL

Definition of Contract Year 1964 program was continued, the 1963 Program Plan was upgraded; and the NRX Demand Networks were upgraded to reflect the above definition.

One program control representative was assigned for detailed schedule coordination of NRX-A-1 and assisted the NRX-A-1 Task Force in preparation of a composite NRX-A-1 network.

Normal bi-weekly PERT reports were prepared and submitted to SNPO-C as required.

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Item 4.2 FISCAL CONTROL

Preparation of the Program Planning Document for CY 1964 was initiated during this report period. The Monthly Fiscal Supplement to the May Progress Letter was prepared and submitted to SNPO-C.

Item 4.3 ADDITIONAL DOCUMENTATION

The following additional documents were prepared and published by REON during the report period.

REON Report No.	Date Transmitted	Title	Report Classification
2585	6-8-63	Evaluation & Comparison of Attitude Control Systems for Spacecraft NERVA Engine	C
2584	6-17-63	Operational Requirements for Radioactive Materials Handling, Decontamination, & Storage, Complex at NRDS	C/RD
2506	6-18-63	Mandatory Facility Additive Engine Test Stand No. 1 at NRDS	S/RD
L0560-10-23	6-18-63	Informal Monthly Progress Letter No. 23	C/RD
L0560-10-23	6-22-63	Reliability & Quality Assurance Supplement to Monthly Progress Letter No. 23	U
L0560-10-23	6-22-63	Fiscal Supplement to Monthly Progress Letter No. 23	U
2592	6-27-63	Radioactive Materials Handling, Decontamination, and Storage Complex - Design Concept & Criteria (Preliminary)	U
2603	6-27-63	Engine Transport System Maintenance Building Design Criteria	U
2743	6-30-63	Data Obtained from First Irradiation Test of Structural Materials	U
2543	6-30-63	Final Report, Generation II NERVA Engine Simulator	C/RD
2320	6-30-63	Instrumentation Data Book (Revised)	C/RD
-33	6-4-63	Weekly Highlights Report (TWX) No. 33	U
-34	6-11-63	Weekly Highlights Report (TWX) No. 34	U

REON Report No.	Date Transmitted	Title	Report Classification
-35	6-18-63	Weekly Highlights Report (TWX) No. 35	U
-36	6-25-63	Weekly Highlights Report (TWX) No. 36	U
-9	6-4-63	Weekly Significant Events & Reactor Component Test Program Progress Report No. 9	C/RD
-10	6-11-63	Progress Report No. 10	C/RD
-11	6-18-63	Progress Report No. 11	C/RD
-12	6-25-63	Progress Report No. 12	C/RD
63-18	6-7-63	PERT Report	C
63-19	6-21-63	PERT Report	C

Item 4.4 CENTRAL DATA SYSTEM

The engineering data, and the documentation system and procedures for review and approval of drawings were transmitted to SNPO-C in preliminary form.

The E.G. & G. drawings have been entered into the engineering data system, and a system has been established for status control.

Item 4.5 SUBCONTRACT ADMINISTRATION

A. SUBCONTRACTS

1. Subcontract NP-1 - Westinghouse

Signed copies of Amendment No. 2 to Supplemental Agreement No. 2 were forwarded for Contracting Officer approval.

Discussions relative to CY 1964 and 1965 and FY 1964 and 1965 were continued.

2. Subcontract NP-2 - Bendix

TPCV Actuator Model NT-B-4 Serial No. 010 was shipped to Azusa on 28 June.

The first set of experimental systems amplifiers was received at Azusa.

The proposed NP-2 work statement for Contract Year 1964 was forwarded to Bendix.

3. Subcontract NP-3 - AMF

The letter subcontract was extended.

Proposed modifications to the AMF Buffalo plant involving rail line extension, switch, and pit are under review.

Three technical service agreements were received.

The proposed Amendment No. 1 to Supplemental Agreement No. 2 was forwarded to AMF.

Approved copies of Supplemental Agreement No. 2 have not yet been received from the contracting officer.

The proposed NP-3 work statement for Contract Year 1963 was forwarded AMF.

4. Subcontract NO-10 - General Electric, Vallecitos

All outstanding contractual issues with General Electric were resolved, and the subcontract was forwarded to General Electric for signature. An advance copy was forwarded to Cleveland.

5. Steam Generator System

Proposals were received from Marquardt and Thiokol. Rocketdyne responded with "no bid."

6. Resistance Temperature Thermometer

A request for proposal was forwarded to General Electric, West Lynn, Mass.

B. REON PURCHASE ORDER ACTIVITY

Originator	No. of P.O.'s	Total Dollar Value
Azusa	1	
LRP	11	
Aetron	1	
Downey		
WANL	29	
Bendix	1	
AMF	3	
E G & G		
GD/FW		
Total	46	$ 946,768.05
Awaiting Action, First of Report Period	11	239,942.00
Action Completed, During Report Period	31	482,253.41
Awaiting Action , End of Report Period	12	451,814.62

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SECTION III (cont.)

TECHNICAL DISCUSSION

TASK 5.0 SPECIAL TEST EQUIPMENT

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Item 5.0 SPECIAL TEST EQUIPMENT
WANL

Work continued on the design of special test equipment for actuator component testing. Additional equipment was designed and ordered for radiation tests at GTR.

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Item 5.1 SPECIAL TEST EQUIPMENT

AGC (LRP-TEST ZONE "C")

Fabrication of the TSOV vessel for Test Stand C-7 is proceeding according to agreements reached at a meeting in Cleveland between personnel of SNPO, AETRON, and REON. These agreements concerned detailed welding callouts, non-destructive testing, and quality assurance controls.

Specifications and contract drawings were completed covering the installation of the TSOV vessel and related piping, and cost quotations were requested during the latter part of the period. Included in the installation will be the relocation and extension of the Test Stand C-7 flare stack over to Test Stand C-6. This is being done to avoid the possibility of exhaust flame damage to C-6 during high-pressure TPA testing on Test Stand C-7.

Design criteria for the installation of Test Stand C-6 supersonic diffuser were prepared and transmitted to AETRON for final design preparation. Actual stand installation of the diffuser has been deferred until the early part of 1964 because of the revised testing program.

Design work progressed on the modification of Test Stand C-6 to accommodate NRX-A nozzle testing, scheduled for September. Design work associated with TPCV testing on Test Stand C-7 was initiated.

Item 5.2 SPECIAL TEST EQUIPMENT
AGC (LRP CRYOGENICS LABORATORY - TEST ZONE "A")

Design efforts associated with TPCV testing were completed, and fabrication of the required STE hardware was initiated.

Bids covering the fabrication and installation of LH_2 transfer piping systems were received. Completion of the contract is expected 90 days after award.

A delay in the completion of the TPCV test setup was caused by late receipt of necessary components from vendor suppliers. Portions of these items were still needed at the close of the report period.

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Item 5.3 SPECIAL TEST EQUIPMENT
AGC (LRP - TEST ZONE "H")

All necessary pieces of vacuum-insulated piping were received in Test Zone "H", which allowed on-stand piping installation work to proceed.

Contractor-installation of the mechanical STE continued throughout the period, with considerable progress noted on GH_2, LN_2, GN_2, LO_2, and GO_2 piping systems. Overall percentage of completion is approximately 90%, as of the end of June.

Efforts were expended in the preparation of contractor-activation procedures. The work encompassed by the activation bid package was presented to the contractor for this price determination.

A second-shift operation was put into effect by the electrical contractor as part of an accelerated effort to complete instrumentation and control STE installation in Test Zone "H".

Completion of contractor-activation of Test Stands H-4, 5, & 6 is presently scheduled for 16 August. Activation by REON personnel will be completed 16 September for TPA testing on test stand H-6.

Aetron began redesign of the hot hydrogen heat exchanger required by recent fabrication specifications of SNPO. As directed by SNPO-C, the high-temperature heater section must be redesigned to conform to latest ASME code requirements. At this time, it is not anticipated that the proposed delivery date of 15 November will be affected.

Contractor-fabrication of the ejector system for Test Stand H-5 was completed, and preparations were made for shipment to AGC-LRP on 1 July.

Fabrication of the gas generator for TPA testing was started. Design of the electrical controls for the TPA test setup was also initiated.

Design work associated with the LH_2 TSOV support systems and modifications to H-4, 5, & 6 for blast effects was completed.

Item 5.4 SPECIAL TEST EQUIPMENT
AGC (STE - AGC), AZUSA PLANT

Component static and dynamic checkouts were made on the first modified PACE 131R computer. The Comcor automatic equipment has proven to be not completely compatible with the E.A.I. Adios automatic set-up unit. Comcor has been notified and is working on a solution to the problem. The 131R computer will be fixed by 19 July 1963.

The shipping date for the second 131R console to Comcor has been tentatively set at 22 July 1963.

Item 5.5 SPECIAL TEST EQUIPMENT
AGC (STE - AGC) DOWNEY PLANT

Approximately 80% of the electronic equipment and instruments, and 30% of the photographic equipment, needed in support of Task Item 1.6 has been received. None of the required meteorological or radiological equipment has yet been acquired. The STE received to date represents an expenditure of approximately 60% of the total funds allocated for Task Item 5.5 STE.

Item 5.8 SPECIAL TEST EQUIPMENT
AGC (LRP BUILDING 3308 - TEMPERATURE LABORATORY)

A decision was reached regarding the fabrication and procurement of the LH_2-Neon cryogenic temperature-calibration facility. Detailed design work and specification preparation was initiated, and the necessary items will be procured from outside vendors. Overall unit fabrication will be completed by LRP. It is expected that nine months will be required to complete the cryostat.

Item 5.9 SPECIAL TEST EQUIPMENT
LRP - CONTROLS AND CHEMICAL LAB (BUILDING 2002)

Design work associated with the special vibration equipment for TCA testing was completed. The control console and data acquisition system are essentially complete.

SECTION III (cont.)

TECHNICAL DISCUSSION

TASK 6.0 GOVERNMENT PROPERTY

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Item 6.2 GOVERNMENT PROPERTY
AGC (LRP - TEST ZONE "A")

Procurement of the hydrogen-leak measurement apparatus was temporarily delayed pending review, by NASA, of the bids submitted. Effort on other items of CY 1963 work was continued throughout the period.

DECLASSIFIED

SECTION IV

PROGRESS STATUS

DECLASSIFIED

IV. PROGRESS STATUS

The accompanying chart present task milestones as selected for the various contract tasks of the contractual Work Statements. Certain of the items cannot be readily programmed by discrete milestone events, and charts have not been prepared for these items.

These milestone charts include those presented with the various NERVA Technical Administration Documents presented in REON Report RN 63002 (C-RD), entitled NERVA Engine Development Program and Associated Tasks, Contract Year 1963 (Revised), March 1963, and all have been expanded and modified as necessary to reflect the redirected program.

These charts have been upgraded to reflect progress through June 1963. Where milestones have been accomplished, the appropriate completion symbols have been added to the chart. If a scheduled milestone has not been accomplished, a re-scheduling has been indicated and a discussion is presented in the following paragraphs.

Task Item 1.1 Engine System

Milestone No. 6 - Complete Fabrication of Dwgs of NRX-A Master P.V. Gages and Submit to SNPO-C

65% of drawings submitted to SNPO-C on 6-18-63. The remainder to be submitted by 7-15-63.

Milestone No. 7 - Fabricate and Ship All NRX-A Master P.V. Gages

Slippage caused by design changes and cancellation of sole source for fabrication.

Milestone No. 14 - Ship Shield Reflector Match Plate

Slippage caused by design changes and cancellation of sole source for fabrication.

Milestone No. 20 - REON Submit Preliminary Test Plans to SNPO-C - NRX-A Vib II

The NRX Program is currently being rescheduled. No firm reschedule dates have been established.

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Milestone No. 24 - REON Submit Preliminary Test Plans to SNPO-C - Block I (NRX-A2, -A3) Test at NRDS

The NRX Program is currently being rescheduled. No firm rescnedule dates have been established.

Milestone No. 26 - REON Submit Preliminary Test Specs to SNPO-C - NRX-A Vib II

The NRX Program is currently being rescheduled. No firm reschedule dates have been established.

Milestone No. 29 - REON Submit Preliminary Test Space Specs to SNPO-C Block I (NRX-A2, -A3) Test at NRDS

The NRX Program is currently being rescheduled. No firm reschedule dates have been established.

Milestone No. 31 - LRP Start Assy of NRX Non-Nuclear Assembly - NRX-A1 Cold Flow

The NRX Program is currently being rescheduled. No firm reschedule dates have been established.

Task Item 1.2 Propellant Feed System

Milestone No. 5 - Establish Acceptance Test Requirements for TPCV

Hardware slippage caused slip in establishing acceptance test requirements.

Milestone No. 9 - Make Tentative Selection of Bearings for Mk IV TPA

Redirection of Mk IV results in reschedule of bearing selection until 8-1-63.

Task Item 1.3 Nuclear Subsystems

Milestone No. 6 - NRX-A Shipping Container Design Report Issued

This milestone slipped pending receipt of design information.

Milestone No. 41 - Test Rig Procurement Complete

This milestone slipped because of a delay in drawing details.

Milestone No. 45 - Test Rig Procurement Complete

Delay in drawing details. These tests are being incorporated into A 1 through revision of WANL-TNR-095.

Milestone No. 47 - Initial Report Issued

No test specimens are available.

Milestone No. 48 - Test Specimen Procurement Complete

Specimens will not be available until August.

Milestone No. 52 - Test Specimen Procurement Complete

Deliquency in vendor delivery schedule.

Milestone No. 57 - Test Rig Procurement Complete

Delay in vendor delivery schedule.

Milestone No. 71 - Test Specimen Procurement Complete

Test specimens not available from supplier.

Milestone No. 72 - Test Rig Procurement Complete

Vendor cannot meet earlier delivery date.

Milestone No. 73 - Test Specimen Procurement Complete

Supplier was unable to meet an earlier delivery schedule.

Milestone No. 89 - Test Specimens Procurement Complete

Cancelled because of program change.

Milestone No. 116 - Hot Flow Program Defined

Cancelled because of program change.

Milestone No. 120 - Complete Procurement of Long Lead Tooling For Bottom Support Plates

Delayed because of vendor delivery schedule.

Milestone No. 138 - Statistical Prediction of Maximum Fuel Temperature Issued

Required greater amount of analysis than originally scheduled.

Milestone No. 176 - NRX-A2 Analysis of Control System Performance During Reactor Start-Up Complete

Delayed pending clarification of requirements.

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Milestone No. 211 - Approval of Design of Instrumentation System Installation by Instrumentation Laboratory

Delay in drawing release.

Milestone No. 212 - Complete Proof Testing and Evaluation Report of Instrumentation

Delayed because of procurement and installation problems.

Milestone No. 213 - Complete Procurement Specification for Instrumentation

Delayed pending selection of candidate transducers.

Milestone No. 214 - Complete Specifications for Acceptance Testing and Calibration of Instrumentation

Pending evaluation of candidate transducers.

Milestone No. 217 - Approval of Design of Instrumentation System Installation by Instrumentation Laboratory

Pending evaluation of candidate transducers.

Milestone No. 219 - Complete Procurement Specification for Instrumentation

Pending evaluation of candidate transducers.

Milestone No. 224 - Complete Procurement Specification for Instrumentation

Pending evaluation of previous instrumentation research.

Milestone No. 238 - Test Specimen Procurement Complete

Pending delivery of specimens from the supplier.

Milestone No. 239 - Test Rig Procurement Complete

Delay caused by the single element corrosion tests.

Milestone No. 255 - Test Specimen Procurement Complete

Delay in analytical preparation.

Milestone No. 256 - Test Rig Procurement Complete

Delay in analytical preparation.

Milestone No. 268 - H_2 Tests Complete

Pending availability of the heat exchanger

Milestone No. 269 - Report Issued

Delayed because of heat exchanger failure.

Milestone No. 276 - Test Specimen Procurement Complete

Pending delivery of specimens from the supplier.

Milestone No. 280 - Reference Fuel Engineering Mechanical and Physical Properties Report Issued

Pending availability of experimental specimens and materials.

Milestone No. 284 - NRX-A Phase I Vibration Core Hardware Procurement Complete

Vendor delivery slippages.

Milestone No. 285 - NRX-A1 Cold Flow Reactor Parts Procurement Complete

Pending delivery of hardware.

Milestone No. 294 - Phase I Core Assembly Complete

Pending delivery of hardware.

Milestone No. 303 - NRX-A2 Hot Test

Pending redefinition of test plan requirements.

Milestone No. 304 - NRX-A3 Cold Flow

Pending redefinition of test plan requirements.

Milestone No. 305 - NRX-A3 Hot Test

Pending redefinition of test plan requirements.

Milestone No. 321 - Complete Design, Procurement and Assembly of a Complete Reactor Mockup for Checkout of NRX-A Assembly/Disassembly Equipment

Procurement delay caused by design changes.

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Task Item 1.4 Thrust Chamber Assembly

Milestone No. 14 - Complete Graphite H_2-O_2 Analysis

Unanticipated testing problems required rework of nozzle after each test.

Task Item 1.5 Engine Controls

Milestone No. 13 - Complete Vendor Capability Study for Engine Harness Components

Delayed because of a late vendor quote.

Task Item 1.7 Pneumatic System

Milestone No. 4 - Complete Detail Designs of Pneumatic System for CFDTS

CFDTS Program delay will permit a later date for the layout and detail drawing of the pneumatic system.

Task Item 1.9 Radiation Effects Program

Milestone No. 3 - Submit Summary Hazards Report on PBRF Additions to SNPO-C

The Preliminary Hazards Report was reviewed by PBRF on 6-17-63. Changes have been incorporated and final report is in publication.

Task Item 2.4 Instrumentation

Milestone No. 16 - Complete Measurements List

NRX-A Vib II test has been cancelled. Milestone cancelled.

Task Item 2.6 Reliability and Quality Assurance

Milestone No. 5 - Complete Design Review for Experimental Bendix Actuators (BPAD)

Delay caused by incomplete detail documentation on NPC (Experimental).

Milestone No. 7 - Complete Design Review of NRX-A1 Cold Flow Non-Nuclear Assembly (LRP)

This milestone due 6-25-63. LRP report period stopped 6-20-63.

Milestone No. 8 - Complete Review of NRX-A1 Cold Flow Acceptance Test Procedure (LRP)

Rescheduled to 8-10-63 because of changes in design engineering activities on which the reliability milestones are based.

Task Item 2.7 Safety

Milestone No. 2 - Issue Revised RIFT Safety Report on NERVA Engine Description

Rescheduled to August to allow incorporation of latest data from revised FX Engine Model Spec. Completed draft revised report available for July review.

Milestone No. 3 - Issue Preliminary NRX-A Safeguards Report

Per SNPO request, report being modified to include complete hazards evaluation for NRX disassembly operations. Report title changed to "Preliminary NRX Safety Analysis Report."

Milestone No. 4 - Issue Initial Source Term Description

Milestone deleted per agreement REON, WANL, and SNPO-C whereby this milestone will be completed by WANL in CY 1964.

Milestone No. 7 - Complete Emergency Plan for NRX-A Tests at NRDS

Milestone deleted because preliminary draft will be contained in NRX Safety Analysis Report. Detailed Emergency Plan will not be issued until after both NRX Safety Analysis Report and revised Nuclear Rocket Development Station Standard have been issued and reviewed.

Milestone No. 9 - Flight Operational Safety Systems Requirements Report

Per agreement between REON and SNPO-C personnel this milestone re-scheduled for completion in September 1964 because extensive amount of analysis required.

Milestone No. 12 - Reactor Assembly Safety Analysis Report Complete

Pending completion of material review and draft preparation.

Milestone No. 13 - Reactor Shipping Safeguards Report Complete

Additional time required to analyze pertinent data.

Milestone No. 14 - Report of Feasibility of Flight Version of a Full Core Nuclear Poison System Issued

Delay in data acquisition and experimental analysis.

Milestone No. 15 - NRX-A Disassembly and Operation Safeguards Preliminary Report Issued

This milestone combined with Milestone 3, so Milestone 15 deleted.

Task Item 2.8 Training

Milestone No. 8 - Complete Study Guides/Visual Aids

Guides and aids were completed in rough form in June. But, desire to revise and improve them based on first two presentations of this course.

Milestone No. 10 - Complete Instructor Lesson Plans

Lesson plans were completed in rough form in June. But, desire to revise and improve them based on first two presentations of this course.

Task Item 3.1 Scale Model Duct Program

Milestone No. 4 - Operation of NES Defined-Scale Model Tests for ETS-1

Unanticipated problems involving disposal of turbine exhaust gases and seal leakage.

Task Item 5.1 STE Test Zone "C" - LRP

Milestone No. 4 - Design LH_2 Piping and Support Systems TS C6-C8

Late receipt of NRX-A Test Development Plan defining the design parameters and physical configuration required to initiate facility design fabrication and installation.

Milestone No. 5 - Design of TCA Adapter Piping

Late receipt of NRX-A Test Development Plan defining the design parameters and physical configuration required to initiate facility design fabrication and installation.

Milestone No. 12 - Activation of NRX-A Cold Flow Test System

Late receipt of NRX-A Test Development Plan defining the design parameters and physical configuration required to initiate facility design fabrication and installation.

Milestone No. 10 - Activation of NRX-A Cold Test I & C Systems

Eliminated because redundant to effort being done in Task 2.4.

Task Item 5.2 STE Cryogenics Laboratory-Test Zone "A" - LRP

Milestone No. 2 - Fabricate and Install TSOV Test System

Delay in receipt from vendor of long lead hardware.

Milestone No. 4 - Fabricate and Install TPCV Test System

Delay in receipt from vendor of long lead hardware.

Milestone No. 5 - Fabricate and Install LH_2 Transfer Piping System

Received bids considerably over control estimate.

Task Item 5.3 STE Test Zone "B" - LRP

Milestone No. 3 - Fabricate and Install Mechanical STE for Test Stands H-4, -5, -6

Delay in construction caused by program redirection and slippages in contractor scheduled performance.

Milestone No. 9 - Fabricate and Install Mechanical Portion PFNTS/TCA

Delay in receipt of design criteria coupled with delay in stand construction.

Milestone No. 10 - Fabricate and Install TCA Adapter Coolant Pipe System

Eliminated because included in Milestone 9 accomplishments.

Milestone No. 18 - Design Electrical Cont. HG Facility TPA Testing

Active design effort deferred because of postponed installation of Lot No. 2 facility.

Task Item 5.4 STE AGC (Azusa Plant) Analog Computer

Milestone No. 4 - Deliver 231R Additional Equipment

SNPO approved last purchase order 6-26-63. Equipment due for delivery 9-15-63.

[redacted]

Milestone No. 5 - Deliver Control System C/O Equipment

Major portion equipment received. Vendor delivery dates delaying remainder of items.

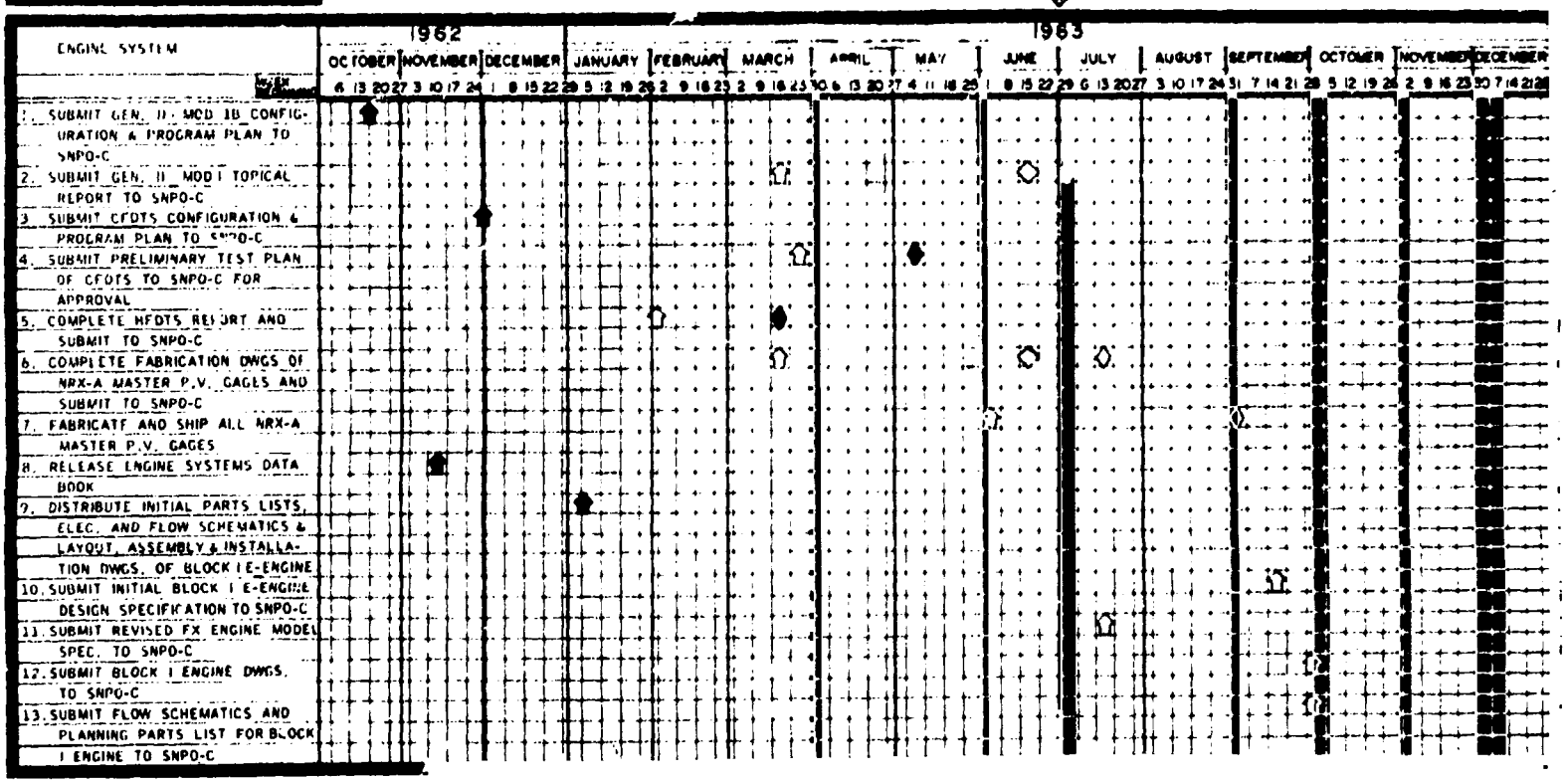
Task Item 6.2 IRP "A" Area

Milestone No. 2 - Fabricate and Install LN_2 System Extension

Received bids higher than control estimate.

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.1


ENGINE SYSTEM
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1. SUBMIT GEN. II MOD IB CONFIGURATION & PROGRAM PLAN TO SNPO-C
2. SUBMIT GEN. II MOD I TOPICAL REPORT TO SNPO-C
3. SUBMIT CFDTS CONFIGURATION & PROGRAM PLAN TO SNPO-C
4. SUBMIT PRELIMINARY TEST PLAN OF CFDTS TO SNPO-C FOR APPROVAL
5. COMPLETE HFDTS REPORT AND SUBMIT TO SNPO-C
6. COMPLETE FABRICATION DWGS OF NRX-A MASTER P.V. GAGES AND SUBMIT TO SNPO-C
7. FABRICATE AND SHIP ALL NRX-A MASTER P.V. GAGES
8. RELEASE ENGINE SYSTEMS DATA BOOK
9. DISTRIBUTE INITIAL PARTS LISTS, ELEC. AND FLOW SCHEMATICS & LAYOUT, ASSEMBLY & INSTALLATION DWGS. OF BLOCK I E-ENGINE
10. SUBMIT INITIAL BLOCK I E-ENGINE DESIGN SPECIFICATION TO SNPO-C
11. SUBMIT REVISED FX ENGINE MODEL SPEC. TO SNPO-C
12. SUBMIT BLOCK I ENGINE DWGS. TO SNPO-C
13. SUBMIT FLOW SCHEMATICS AND PLANNING PARTS LIST FOR BLOCK I ENGINE TO SNPO-C

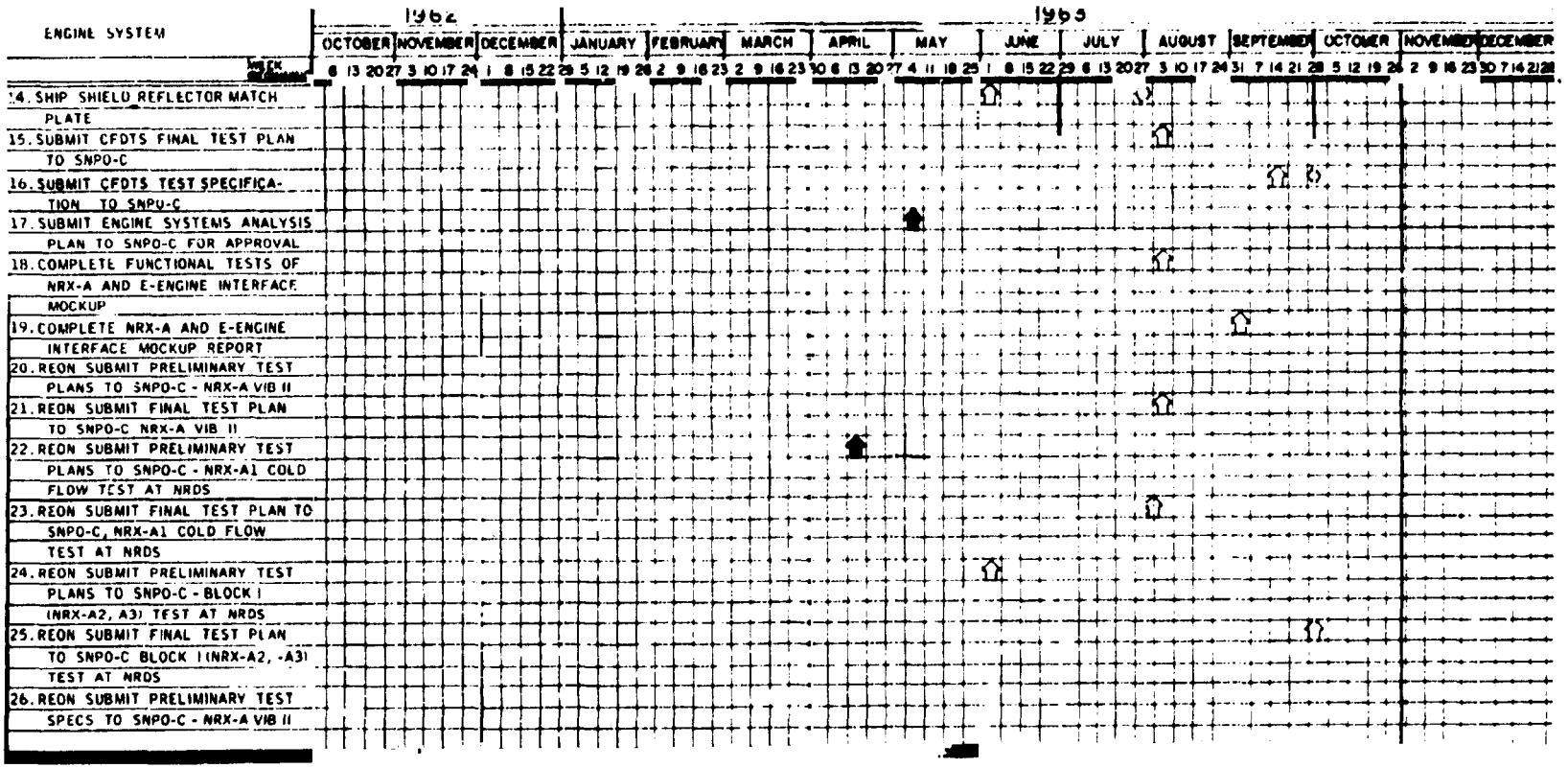
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 1 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.1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14. SHIP SHIELD REFLECTOR MATCH PLATE
15. SUBMIT CFDTS FINAL TEST PLAN TO SNPO-C
16. SUBMIT CFDTS TEST SPECIFICATION TO SNPO-C
17. SUBMIT ENGINE SYSTEMS ANALYSIS PLAN TO SNPO-C FOR APPROVAL
18. COMPLETE FUNCTIONAL TESTS OF NRX-A AND E-ENGINE INTERFACE MOCKUP
19. COMPLETE NRX-A AND E-ENGINE INTERFACE MOCKUP REPORT
20. REON SUBMIT PRELIMINARY TEST PLANS TO SNPO-C - NRX-A VIB II
21. REON SUBMIT FINAL TEST PLAN TO SNPO-C NRX-A VIB II
22. REON SUBMIT PRELIMINARY TEST PLANS TO SNPO-C - NRX-A1 COLD FLOW TEST AT NRDS
23. REON SUBMIT FINAL TEST PLAN TO SNPO-C, NRX-A1 COLD FLOW TEST AT NRDS
24. REON SUBMIT PRELIMINARY TEST PLANS TO SNPO-C - BLOCK I (NRX-A2, A3) TEST AT NRDS
25. REON SUBMIT FINAL TEST PLAN TO SNPO-C BLOCK I (NRX-A2, -A3) TEST AT NRDS
26. REON SUBMIT PRELIMINARY TEST SPECS TO SNPO-C - NRX-A VIB II

◇ SCHEDULED MILESTONE
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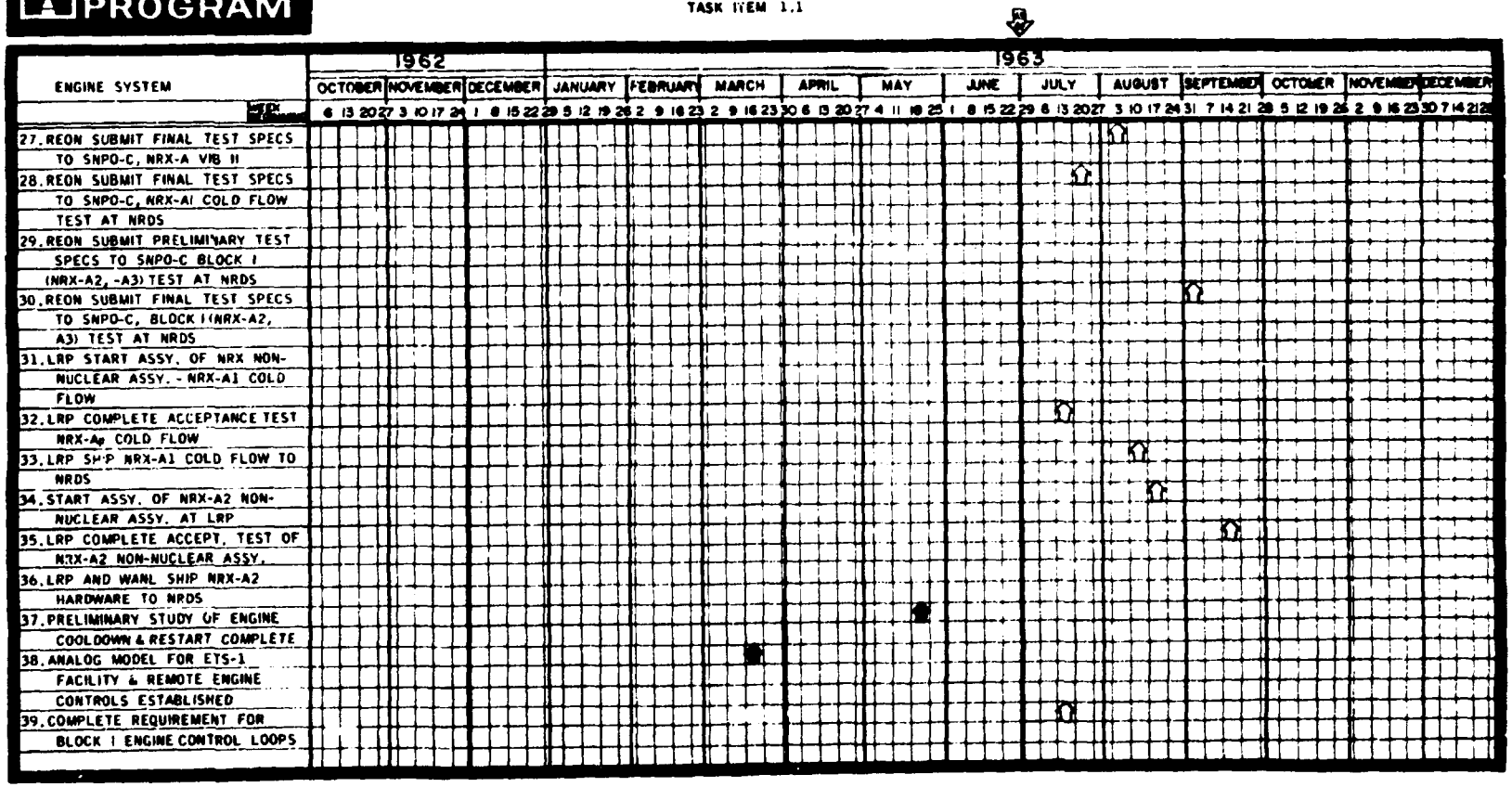
◇ RESCHEDULED MILFSTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 2 o

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.1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27. REON SUBMIT FINAL TEST SPECS TO SNPO-C, NRX-A VIB II
28. REON SUBMIT FINAL TEST SPECS TO SNPO-C, NRX-A1 COLD FLOW TEST AT NRDS
29. REON SUBMIT PRELIMINARY TEST SPECS TO SNPO-C BLOCK I (NRX-A2, -A3) TEST AT NRDS
30. REON SUBMIT FINAL TEST SPECS TO SNPO-C, BLOCK I (NRX-A2, A3) TEST AT NRDS
31. LRP START ASSY. OF NRX NON-NUCLEAR ASSY. - NRX-A1 COLD FLOW
32. LRP COMPLETE ACCEPTANCE TEST NRX-A2 COLD FLOW
33. LRP SHIP NRX-A1 COLD FLOW TO NRDS
34. START ASSY. OF NRX-A2 NON-NUCLEAR ASSY. AT LRP
35. LRP COMPLETE ACCEPT. TEST OF NRX-A2 NON-NUCLEAR ASSY.
36. LRP AND WANL SHIP NRX-A2 HARDWARE TO NRDS
37. PRELIMINARY STUDY OF ENGINE COOLDOWN & RESTART COMPLETE
38. ANALOG MODEL FOR ETS-1 FACILITY & REMOTE ENGINE CONTROLS ESTABLISHED
39. COMPLETE REQUIREMENT FOR BLOCK I ENGINE CONTROL LOOPS

DATE:

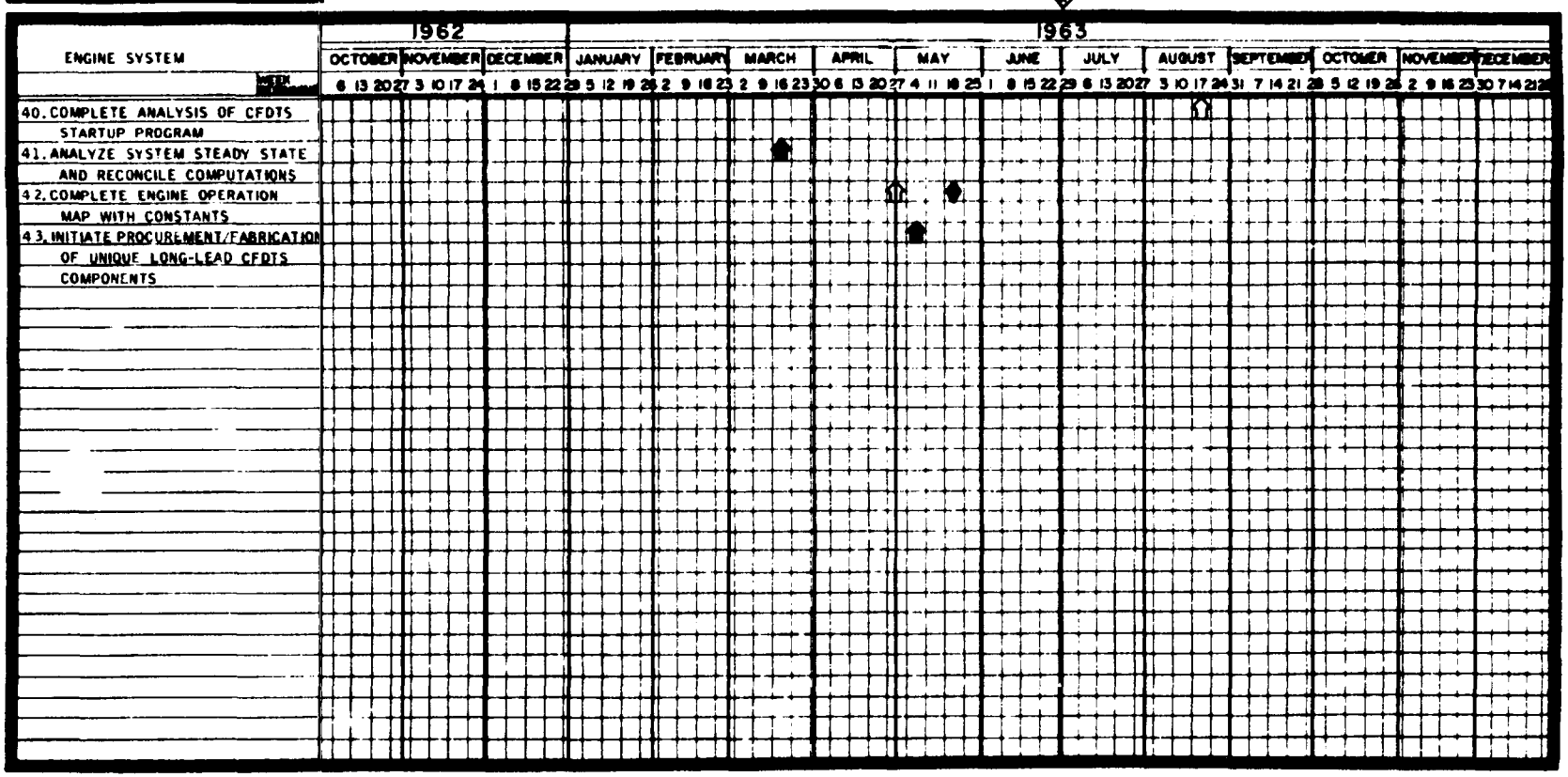
⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 3 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.1



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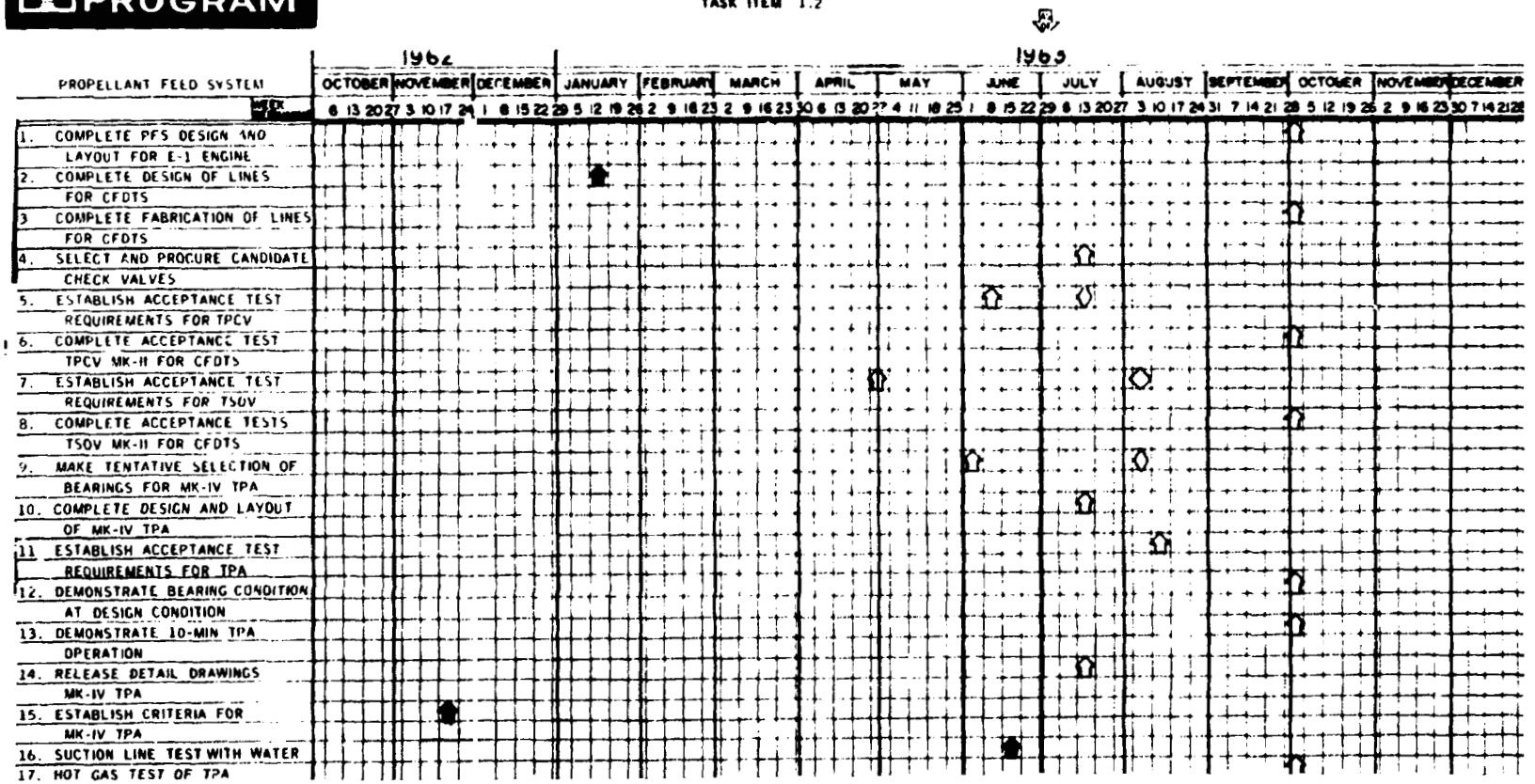
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 4 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.2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PROPELLANT FEED SYSTEM
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1. COMPLETE PFS DESIGN AND LAYOUT FOR E-1 ENGINE
2. COMPLETE DESIGN OF LINES FOR CFDTS
3 COMPLETE FABRICATION OF LINES FOR CFDTS
4. SELECT AND PROCURE CANDIDATE CHECK VALVES
5. ESTABLISH ACCEPTANCE TEST REQUIREMENTS FOR TPCV
6. COMPLETE ACCEPTANCE TEST TPCV MK-II FOR CFDTS
7. ESTABLISH ACCEPTANCE TEST REQUIREMENTS FOR TSOV
8. COMPLETE ACCEPTANCE TESTS TSOV MK-II FOR CFDTS
9. MAKE TENTATIVE SELECTION OF BEARINGS FOR MK-IV TPA
10. COMPLETE DESIGN AND LAYOUT OF MK-IV TPA
11 ESTABLISH ACCEPTANCE TEST REQUIREMENTS FOR TPA
12. DEMONSTRATE BEARING CONDITION AT DESIGN CONDITION
13. DEMONSTRATE 10-MIN TPA OPERATION
14. RELEASE DETAIL DRAWINGS MK-IV TPA
15. ESTABLISH CRITERIA FOR MK-IV TPA
16. SUCTION LINE TEST WITH WATER
17. HOT GAS TEST OF TPA

DATE:

⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
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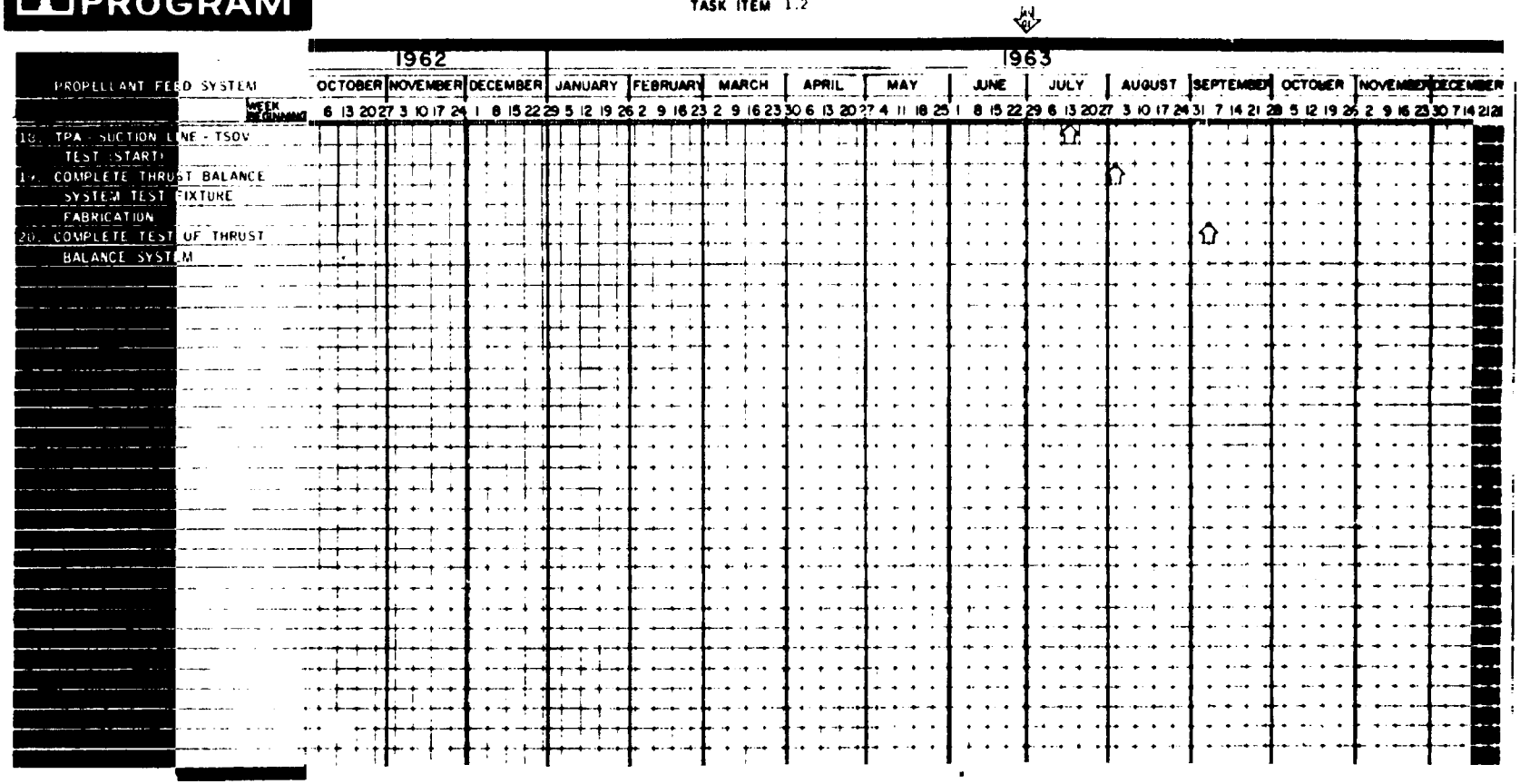
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 5 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.2


PROPELLANT FEED SYSTEM
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18. TPA - SUCTION LINE - TSOV
TEST (START)
19. COMPLETE THRUST BALANCE
SYSTEM TEST FIXTURE
FABRICATION
20. COMPLETE TEST OF THRUST
BALANCE SYSTEM

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◇ SCHEDULED MILESTONE
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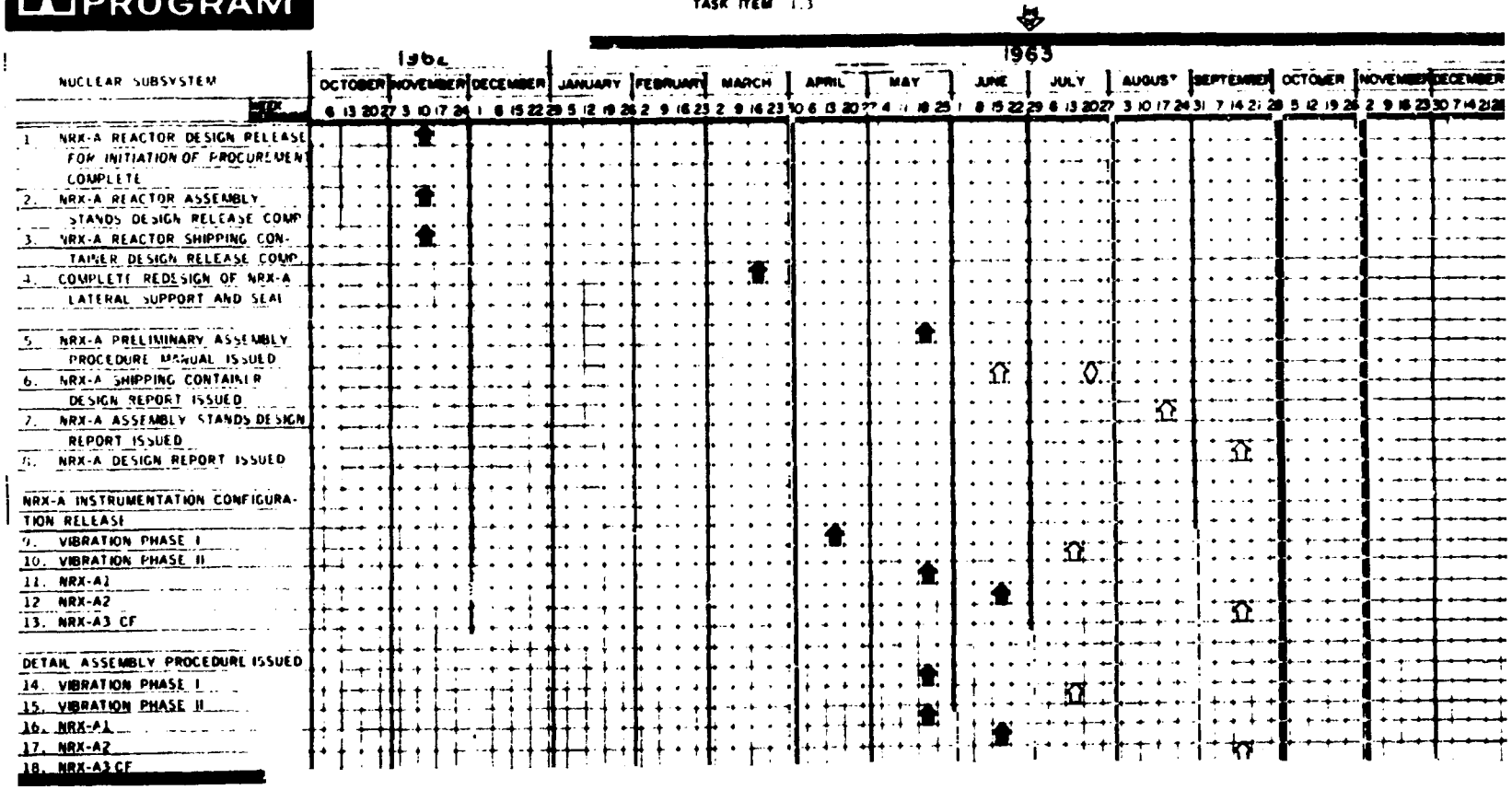
Figure 1
Sheet 6 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
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OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
NUCLEAR SUBSYSTEM
1. NRX-A REACTOR DESIGN RELEASE FOR INITIATION OF PROCUREMENT COMPLETE
2. NRX-A REACTOR ASSEMBLY STANDS DESIGN RELEASE COMP
3. NRX-A REACTOR SHIPPING CONTAINER DESIGN RELEASE COMP
4. COMPLETE REDESIGN OF NRX-A LATERAL SUPPORT AND SEAL
5. NRX-A PRELIMINARY ASSEMBLY PROCEDURE MANUAL ISSUED
6. NRX-A SHIPPING CONTAINER DESIGN REPORT ISSUED
7. NRX-A ASSEMBLY STANDS DESIGN REPORT ISSUED
8. NRX-A DESIGN REPORT ISSUED
NRX-A INSTRUMENTATION CONFIGURATION RELEASE
9. VIBRATION PHASE I
10. VIBRATION PHASE II
11. NRX-A1
12. NRX-A2
13. NRX-A3 CF
DETAIL ASSEMBLY PROCEDURE ISSUED
14. VIBRATION PHASE I
15. VIBRATION PHASE II
16. NRX-A1
17. NRX-A2
18. NRX-A3 CF

DATE:

⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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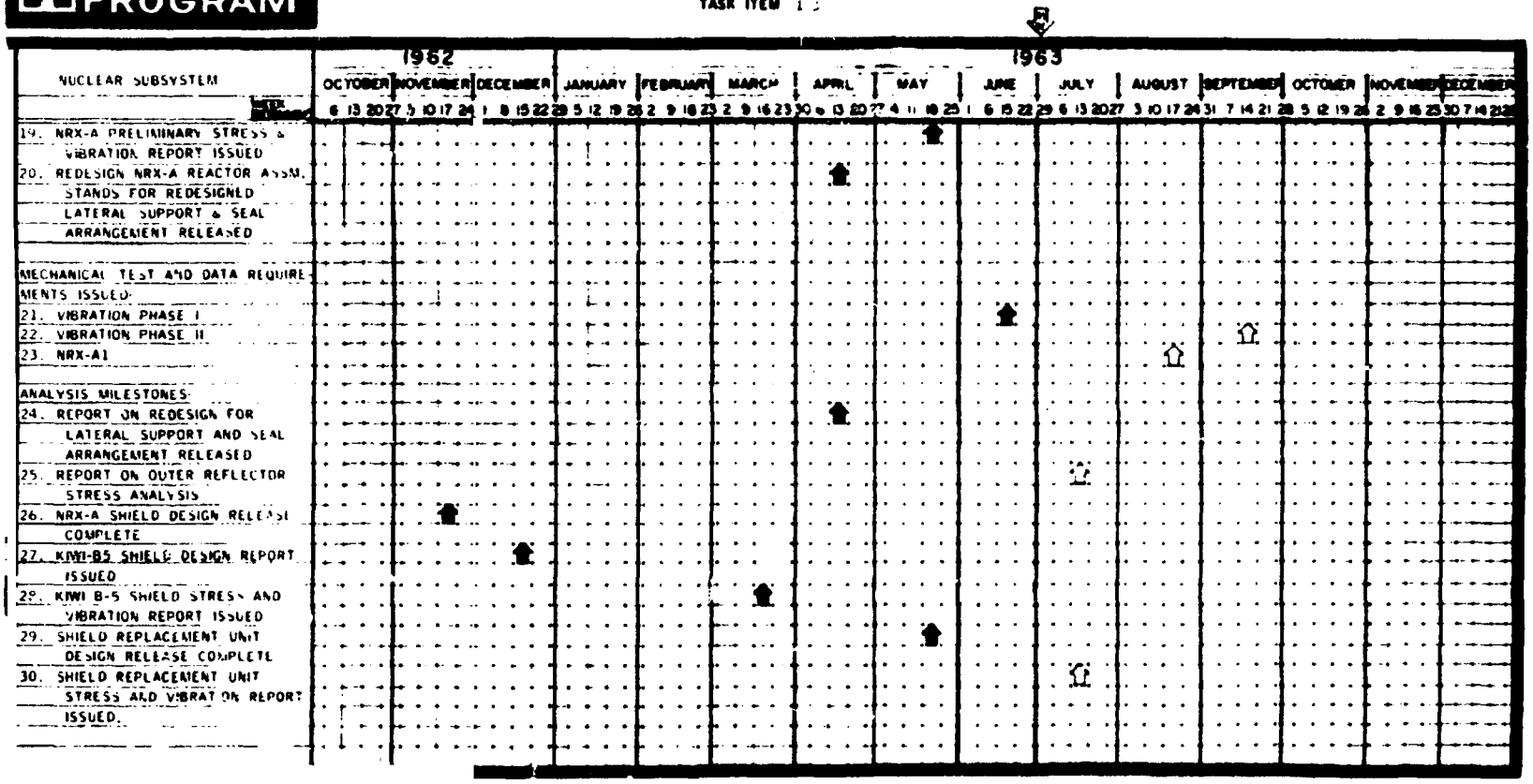
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM [redacted]


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21
19. NRX-A PRELIMINARY STRESS & VIBRATION REPORT ISSUED
20. REDESIGN NRX-A REACTOR ASSM. STANDS FOR REDESIGNED LATERAL SUPPORT & SEAL ARRANGEMENT RELEASED
MECHANICAL TEST AND DATA REQUIREMENTS ISSUED:
21. VIBRATION PHASE I
22. VIBRATION PHASE II
23. NRX-A1
ANALYSIS MILESTONES:
24. REPORT ON REDESIGN FOR LATERAL SUPPORT AND SEAL ARRANGEMENT RELEASED
25. REPORT ON OUTER REFLECTOR STRESS ANALYSIS
26. NRX-A SHIELD DESIGN RELEASE COMPLETE
27. KIWI-B5 SHIELD DESIGN REPORT ISSUED
29. KIWI B-5 SHIELD STRESS AND VIBRATION REPORT ISSUED
29. SHIELD REPLACEMENT UNIT DESIGN RELEASE COMPLETE
30. SHIELD REPLACEMENT UNIT STRESS AND VIBRATION REPORT ISSUED.

DATE:

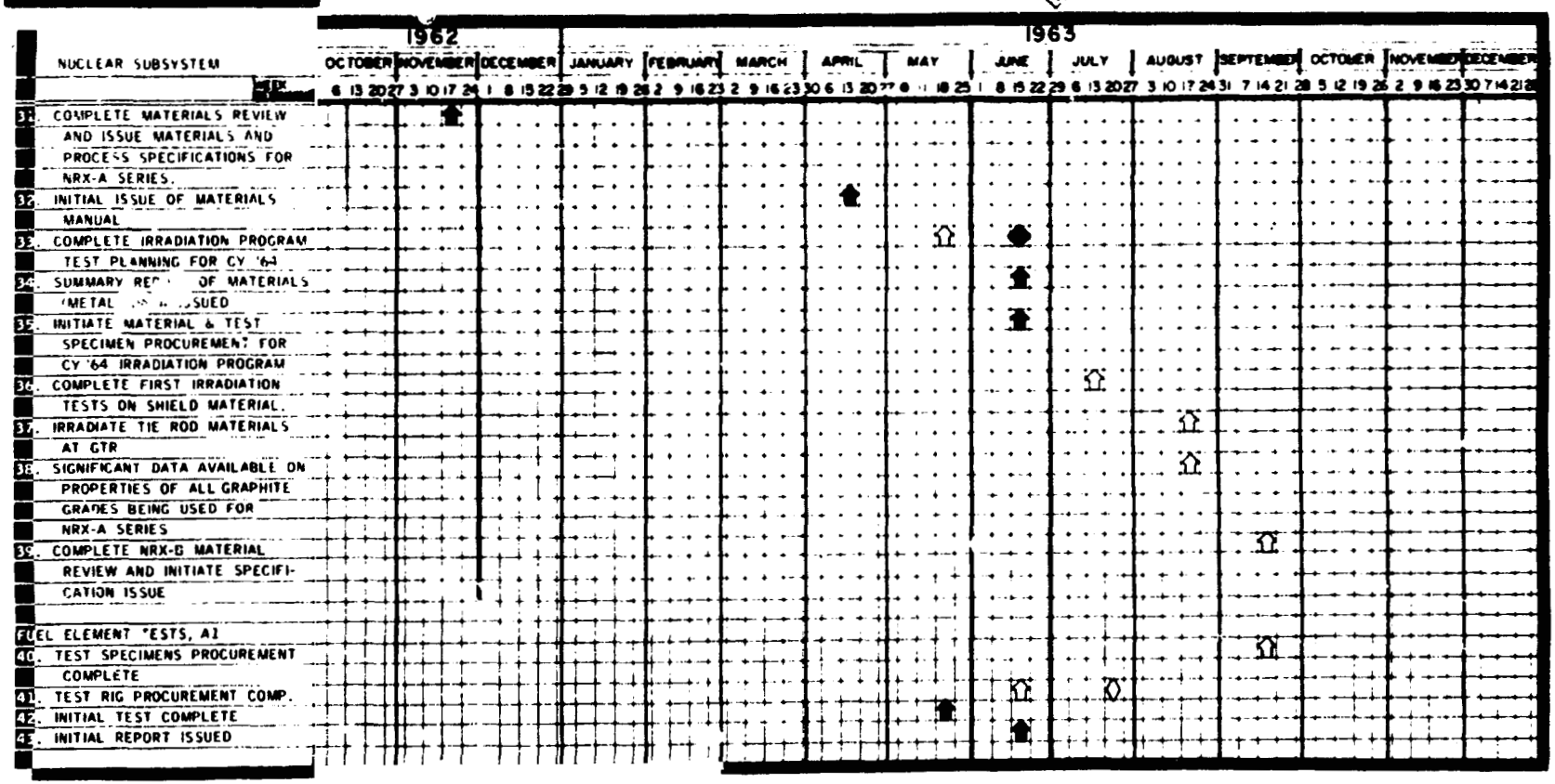
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 3
Sheet 8 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
NUCLEAR SUBSYSTEM
34. COMPLETE MATERIALS REVIEW AND ISSUE MATERIALS AND PROCESS SPECIFICATIONS FOR NRX-A SERIES.
35. INITIAL ISSUE OF MATERIALS MANUAL
36. COMPLETE IRRADIATION PROGRAM TEST PLANNING FOR CY '64
37. SUMMARY REPORT OF MATERIALS (METAL ... ISSUED
38. INITIATE MATERIAL & TEST SPECIMEN PROCUREMENT FOR CY '64 IRRADIATION PROGRAM
39. COMPLETE FIRST IRRADIATION TESTS ON SHIELD MATERIAL.
37. IRRADIATE TIE ROD MATERIALS AT GTR
38. SIGNIFICANT DATA AVAILABLE ON PROPERTIES OF ALL GRAPHITE GRADES BEING USED FOR NRX-A SERIES
39. COMPLETE NRX-B MATERIAL REVIEW AND INITIATE SPECIFICATION ISSUE
FUEL ELEMENT TESTS, A1
40. TEST SPECIMENS PROCUREMENT COMPLETE
41. TEST RIG PROCUREMENT COMP.
42. INITIAL TEST COMPLETE
43. INITIAL REPORT ISSUED

DATE:

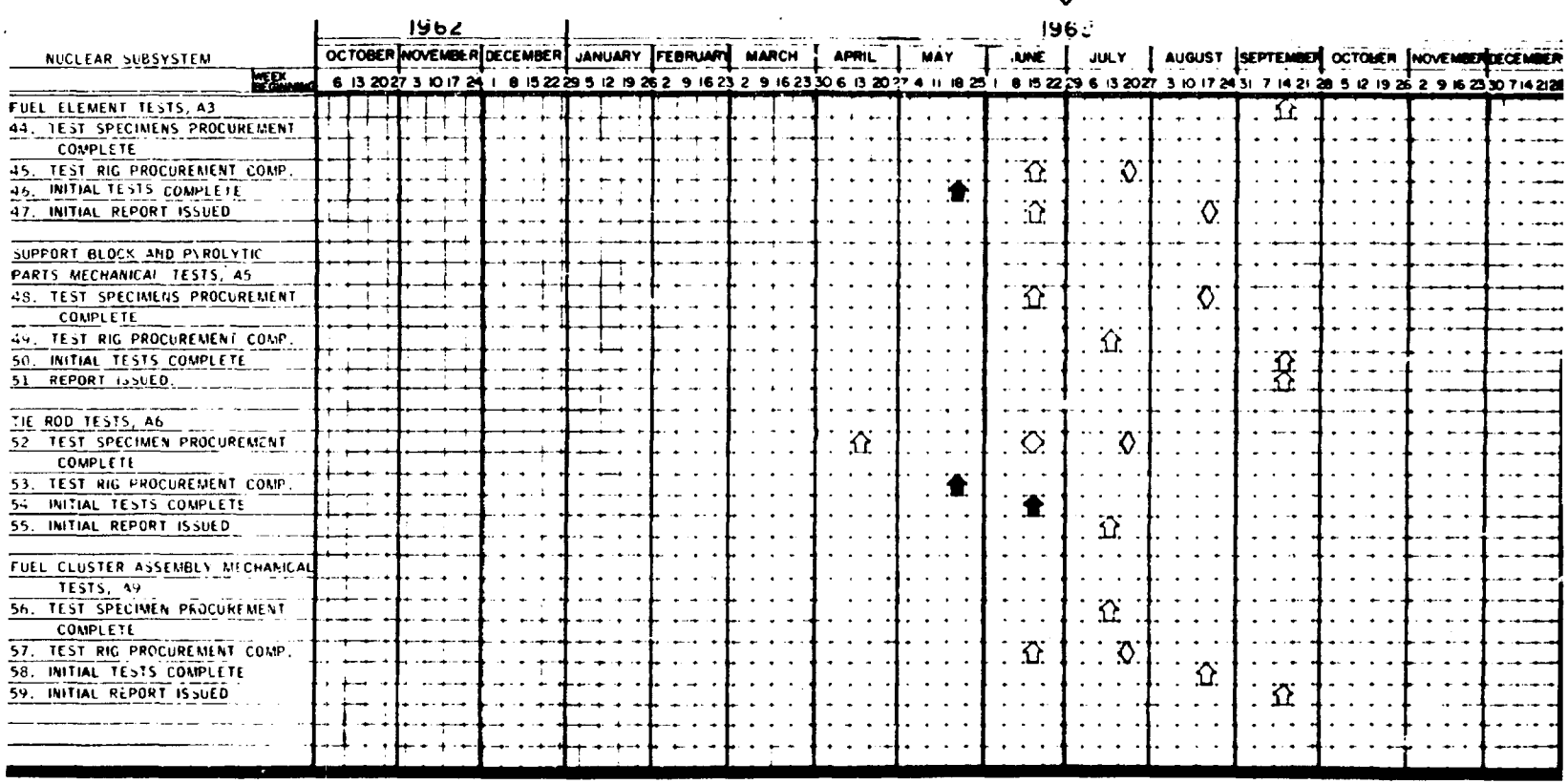
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT
⬆ MILESTONE ACHIEVEMENT

Figure 1
Sheet 9 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
WEEK BEGINNING
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
FUEL ELEMENT TESTS, A3
44. TEST SPECIMENS PROCUREMENT COMPLETE
45. TEST RIG PROCUREMENT COMP.
46. INITIAL TESTS COMPLETE
47. INITIAL REPORT ISSUED
SUPPORT BLOCK AND PYROLYTIC PARTS MECHANICAL TESTS, A5
48. TEST SPECIMENS PROCUREMENT COMPLETE
49. TEST RIG PROCUREMENT COMP.
50. INITIAL TESTS COMPLETE
51. REPORT ISSUED
TIE ROD TESTS, A6
52. TEST SPECIMEN PROCUREMENT COMPLETE
53. TEST RIG PROCUREMENT COMP.
54. INITIAL TESTS COMPLETE
55. INITIAL REPORT ISSUED
FUEL CLUSTER ASSEMBLY MECHANICAL TESTS, A9
56. TEST SPECIMEN PROCUREMENT COMPLETE
57. TEST RIG PROCUREMENT COMP.
58. INITIAL TESTS COMPLETE
59. INITIAL REPORT ISSUED

DATE:

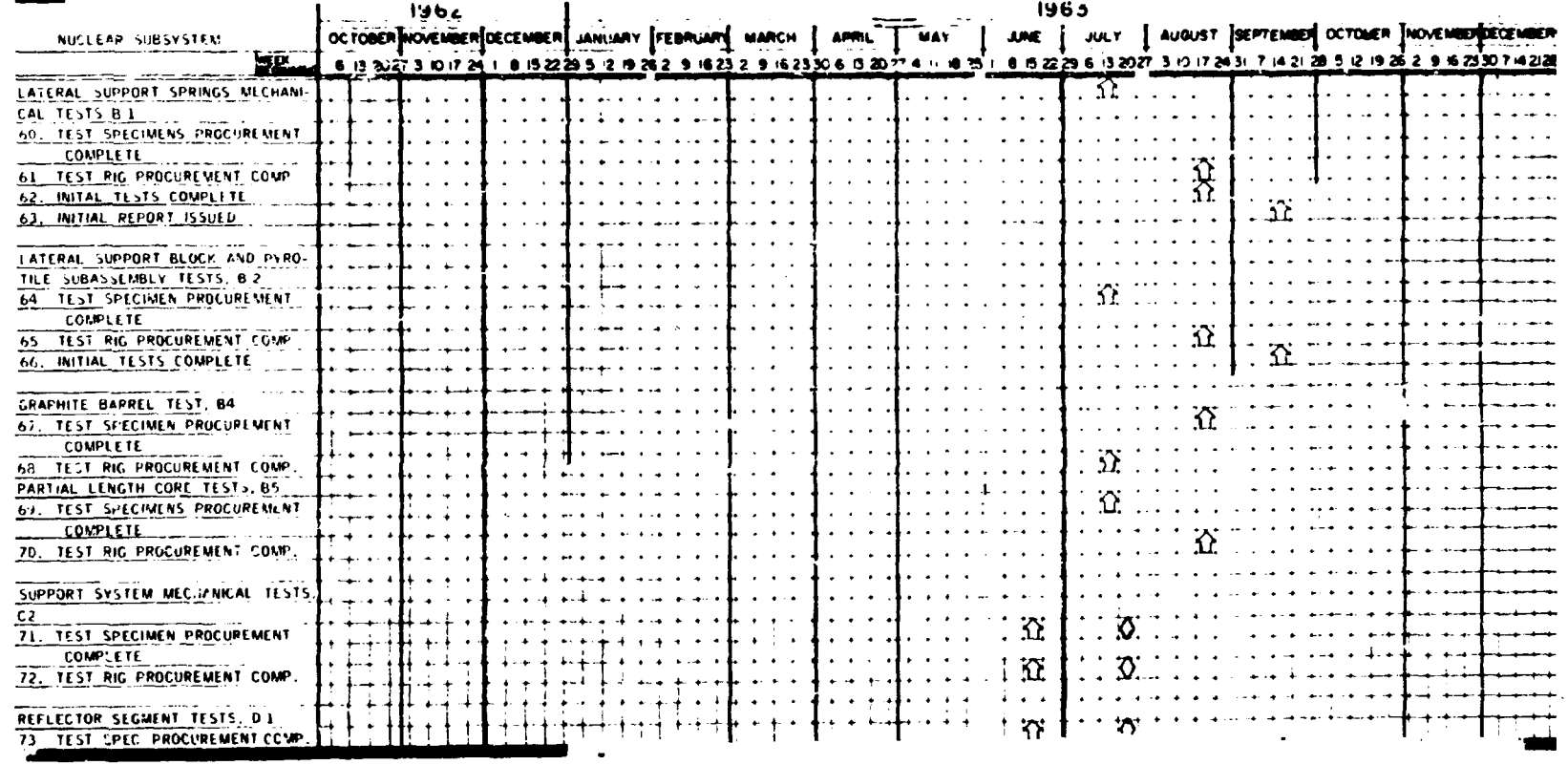
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 10 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1964
1965
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK
NUCLEAR SUBSYSTEM
LATERAL SUPPORT SPRINGS MECHANICAL TESTS B 1
60. TEST SPECIMENS PROCUREMENT COMPLETE
61. TEST RIG PROCUREMENT COMP
62. INITAL TESTS COMPLETE
63. INITIAL REPORT ISSUED
LATERAL SUPPORT BLOCK AND PYROTILE SUBASSEMBLY TESTS, B 2
64. TEST SPECIMEN PROCUREMENT COMPLETE
65. TEST RIG PROCUREMENT COMP.
66. INITIAL TESTS COMPLETE
GRAPHITE BARREL TEST, B4
67. TEST SPECIMEN PROCUREMENT COMPLETE
68. TEST RIG PROCUREMENT COMP.
PARTIAL LENGTH CORE TESTS, B5
69. TEST SPECIMENS PROCUREMENT COMPLETE
70. TEST RIG PROCUREMENT COMP.
SUPPORT SYSTEM MECHANICAL TESTS, C2
71. TEST SPECIMEN PROCUREMENT COMPLETE
72. TEST RIG PROCUREMENT COMP.
REFLECTOR SEGMENT TESTS, D 1
73 TEST SPEC PROCUREMENT COMP.

DATE:

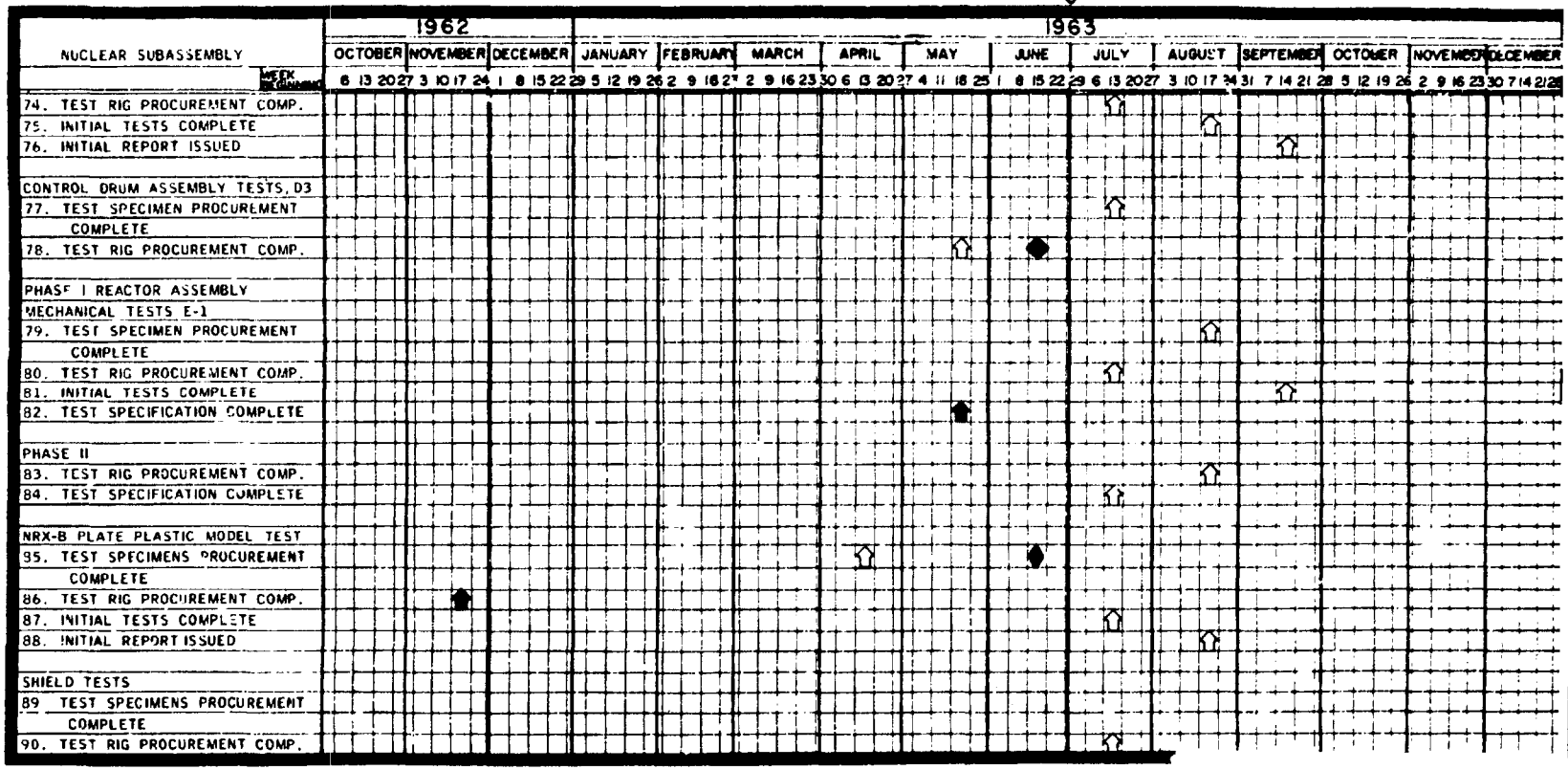
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 11 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBASSEMBLY
WEEK BEGINNING
OCTOBER
NOVEMBER
DECEMBER
JANUARY
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MARCH
APRIL
MAY
JUNE
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OCTOBER
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DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 27 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
74. TEST RIG PROCUREMENT COMP.
75. INITIAL TESTS COMPLETE
76. INITIAL REPORT ISSUED
CONTROL DRUM ASSEMBLY TESTS, D3
77. TEST SPECIMEN PROCUREMENT COMPLETE
78. TEST RIG PROCUREMENT COMP.
PHASE I REACTOR ASSEMBLY
MECHANICAL TESTS E-1
79. TEST SPECIMEN PROCUREMENT COMPLETE
80. TEST RIG PROCUREMENT COMP.
81. INITIAL TESTS COMPLETE
82. TEST SPECIFICATION COMPLETE
PHASE II
83. TEST RIG PROCUREMENT COMP.
84. TEST SPECIFICATION COMPLETE
NRX-B PLATE PLASTIC MODEL TEST
95. TEST SPECIMENS PROCUREMENT COMPLETE
86. TEST RIG PROCUREMENT COMP.
87. INITIAL TESTS COMPLETE
88. INITIAL REPORT ISSUED
SHIELD TESTS
89 TEST SPECIMENS PROCUREMENT COMPLETE
90. TEST RIG PROCUREMENT COMP.

DATE:

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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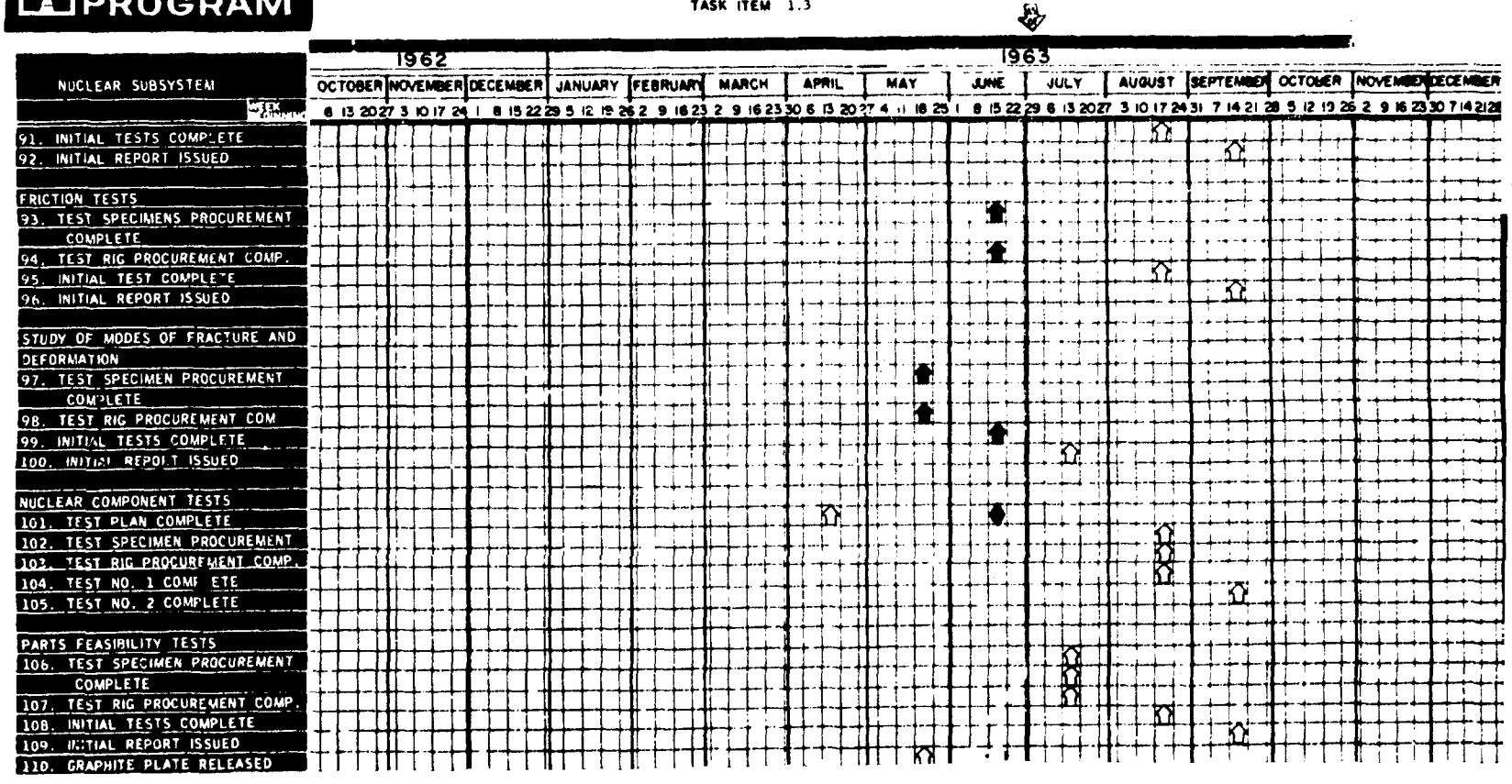
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3



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◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
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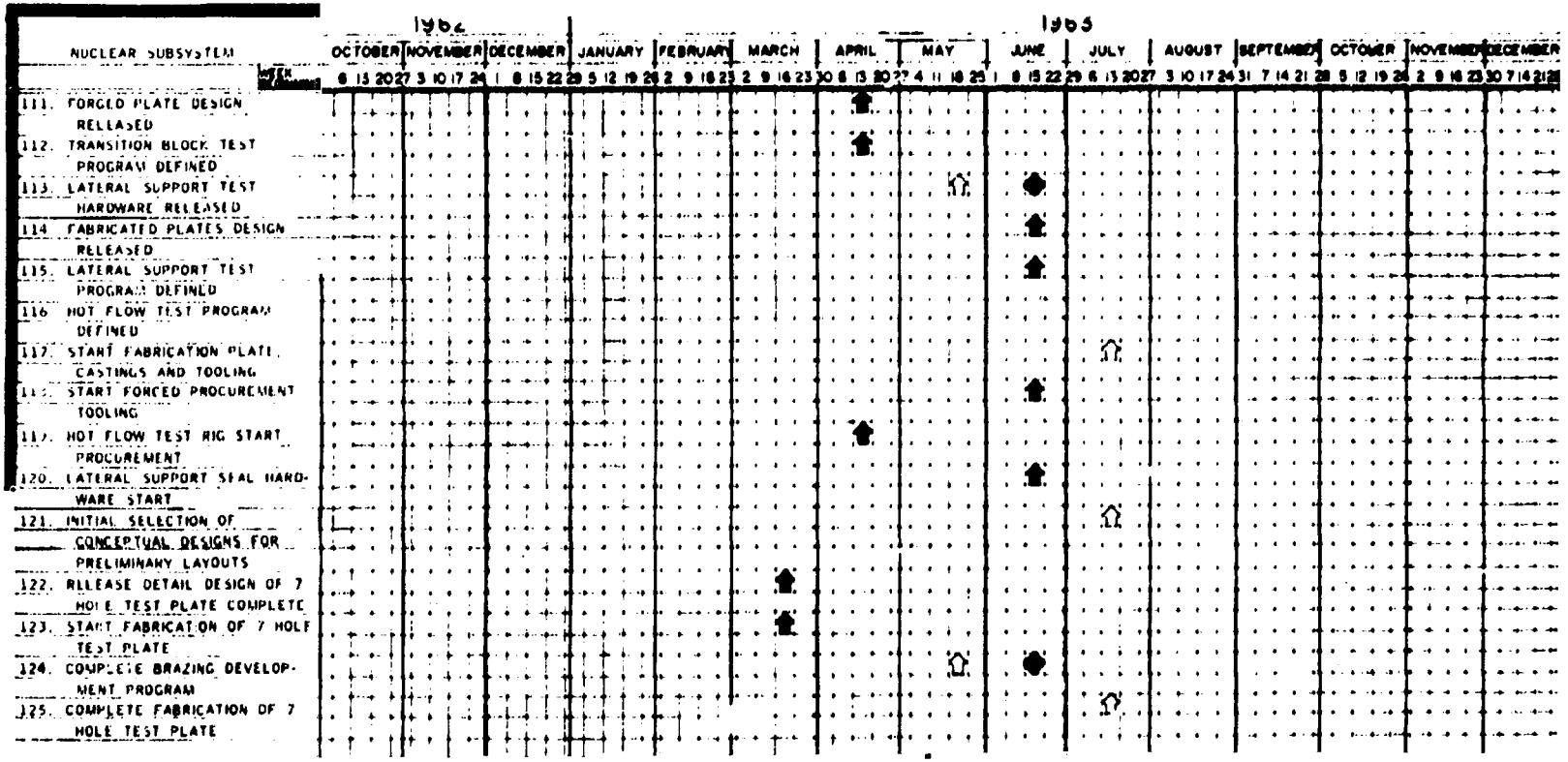
Figure 1
Sheet 13 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
111. FORGED PLATE DESIGN RELEASED
112. TRANSITION BLOCK TEST PROGRAM DEFINED
113. LATERAL SUPPORT TEST HARDWARE RELEASED
114. FABRICATED PLATES DESIGN RELEASED
115. LATERAL SUPPORT TEST PROGRAM DEFINED
116. HOT FLOW TEST PROGRAM DEFINED
117. START FABRICATION PLATE CASTINGS AND TOOLING
118. START FORCED PROCUREMENT TOOLING
119. HOT FLOW TEST RIG START PROCUREMENT
120. LATERAL SUPPORT SEAL HARDWARE START
121. INITIAL SELECTION OF CONCEPTUAL DESIGNS FOR PRELIMINARY LAYOUTS
122. RELEASE DETAIL DESIGN OF 7 HOLE TEST PLATE COMPLETE
123. START FABRICATION OF 7 HOLE TEST PLATE
124. COMPLETE BRAZING DEVELOPMENT PROGRAM
125. COMPLETE FABRICATION OF 7 HOLE TEST PLATE

DATE:

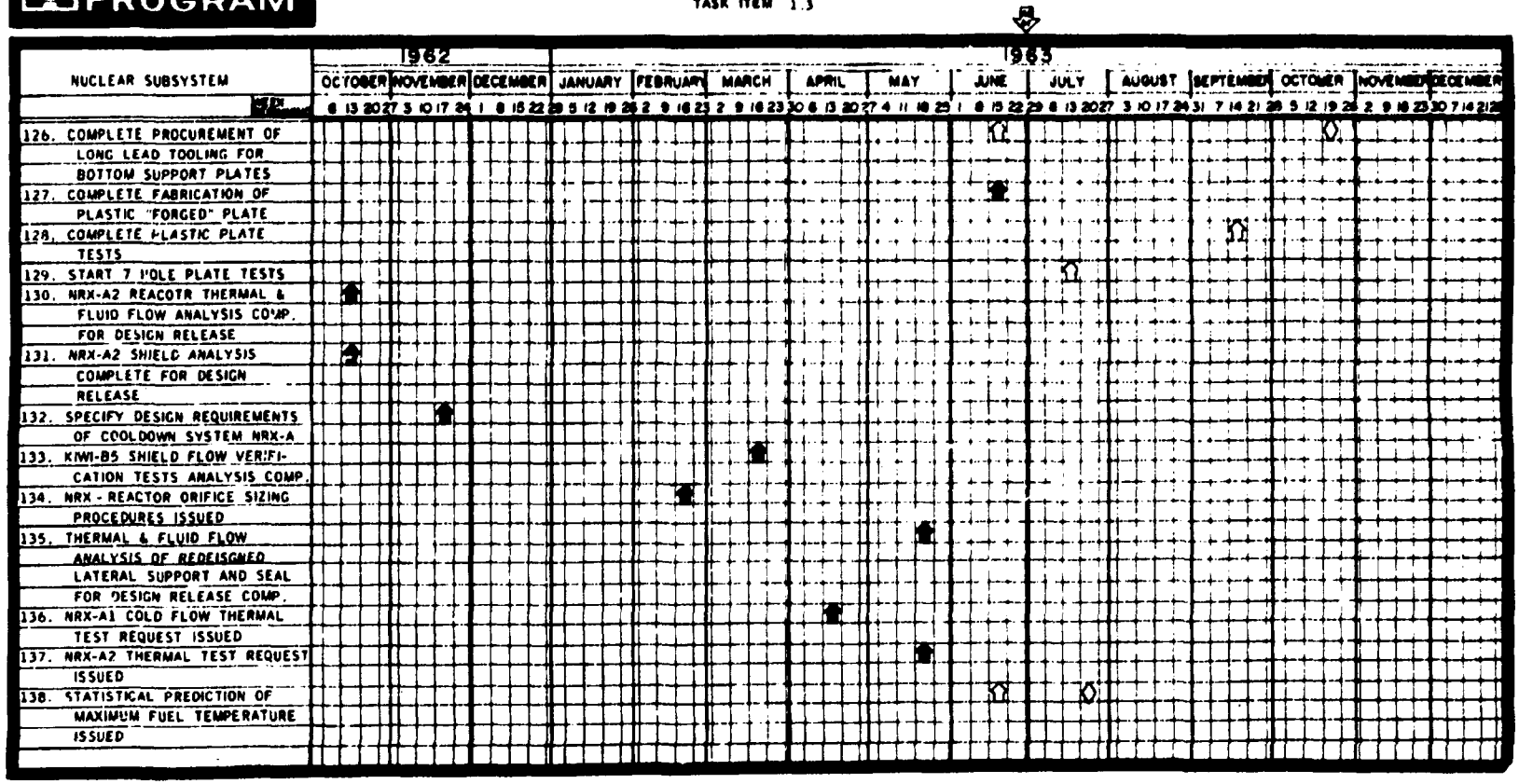
⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 14 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
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OCTOBER
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SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
NUCLEAR SUBSYSTEM
126. COMPLETE PROCUREMENT OF LONG LEAD TOOLING FOR BOTTOM SUPPORT PLATES
127. COMPLETE FABRICATION OF PLASTIC "FORGED" PLATE
128. COMPLETE PLASTIC PLATE TESTS
129. START 7 HOLE PLATE TESTS
130. NRX-A2 REACOTR THERMAL & FLUID FLOW ANALYSIS COMP. FOR DESIGN RELEASE
131. NRX-A2 SHIELD ANALYSIS COMPLETE FOR DESIGN RELEASE
132. SPECIFY DESIGN REQUIREMENTS OF COOLDOWN SYSTEM NRX-A
133. KIWI-B5 SHIELD FLOW VERIFICATION TESTS ANALYSIS COMP.
134. NRX - REACTOR ORIFICE SIZING PROCEDURES ISSUED
135. THERMAL & FLUID FLOW ANALYSIS OF REDESIGNED LATERAL SUPPORT AND SEAL FOR DESIGN RELEASE COMP.
136. NRX-A1 COLD FLOW THERMAL TEST REQUEST ISSUED
137. NRX-A2 THERMAL TEST REQUEST ISSUED
138. STATISTICAL PREDICTION OF MAXIMUM FUEL TEMPERATURE ISSUED

DATE:

⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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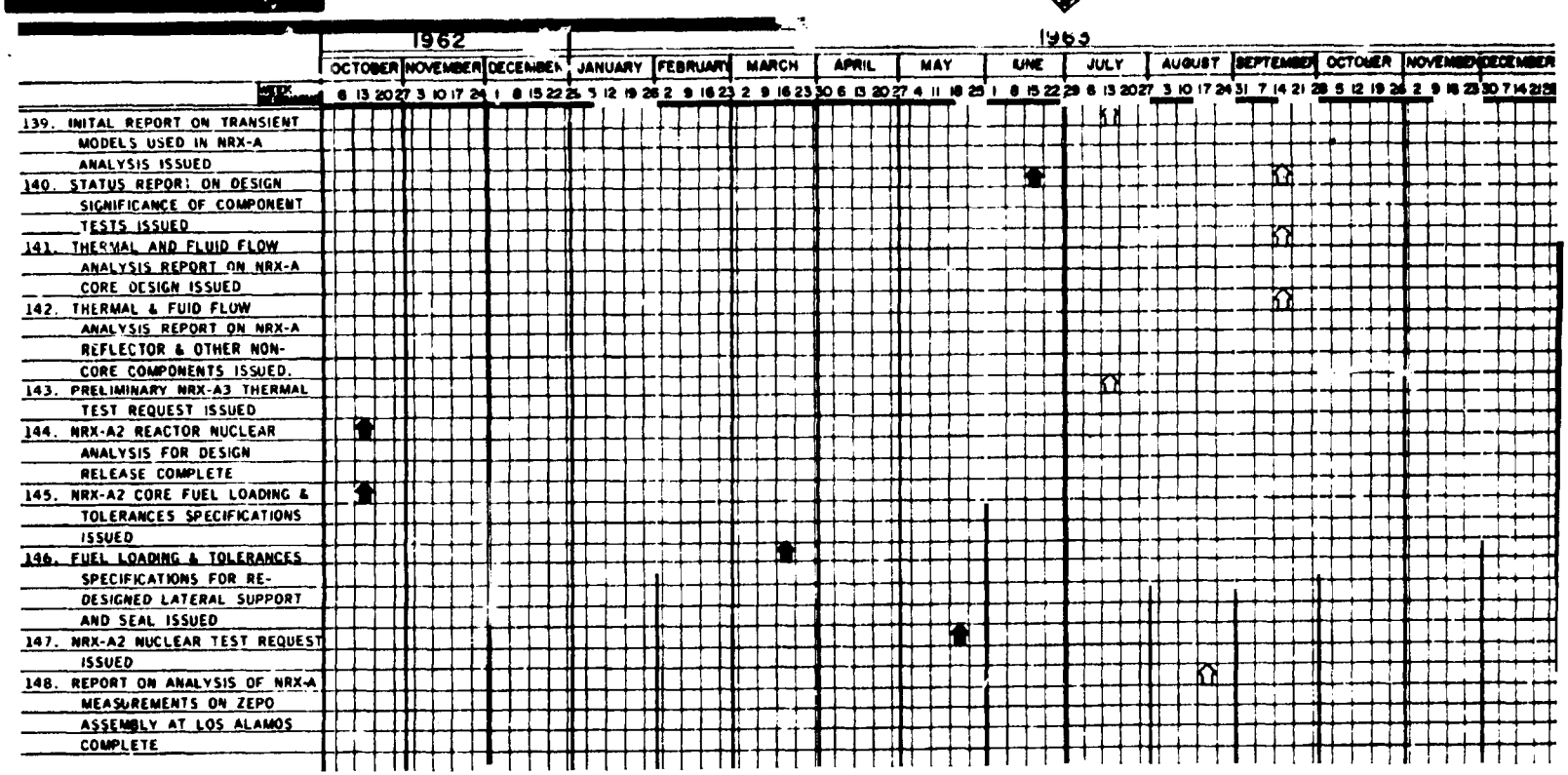
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
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DECEMBER
JANUARY
FEBRUARY
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APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
139. INITAL REPORT ON TRANSIENT MODELS USED IN NRX-A ANALYSIS ISSUED
140. STATUS REPORT ON DESIGN SIGNIFICANCE OF COMPONENT TESTS ISSUED
141. THERMAL AND FLUID FLOW ANALYSIS REPORT ON NRX-A CORE DESIGN ISSUED
142. THERMAL & FUID FLOW ANALYSIS REPORT ON NRX-A REFLECTOR & OTHER NON-CORE COMPONENTS ISSUED.
143. PRELIMINARY NRX-A3 THERMAL TEST REQUEST ISSUED
144. NRX-A2 REACTOR NUCLEAR ANALYSIS FOR DESIGN RELEASE COMPLETE
145. NRX-A2 CORE FUEL LOADING & TOLERANCES SPECIFICATIONS ISSUED
146. FUEL LOADING & TOLERANCES SPECIFICATIONS FOR RE-DESIGNED LATERAL SUPPORT AND SEAL ISSUED
147. NRX-A2 NUCLEAR TEST REQUEST ISSUED
148. REPORT ON ANALYSIS OF NRX-A MEASUREMENTS ON ZEPO ASSEMBLY AT LOS ALAMOS COMPLETE

DATE:

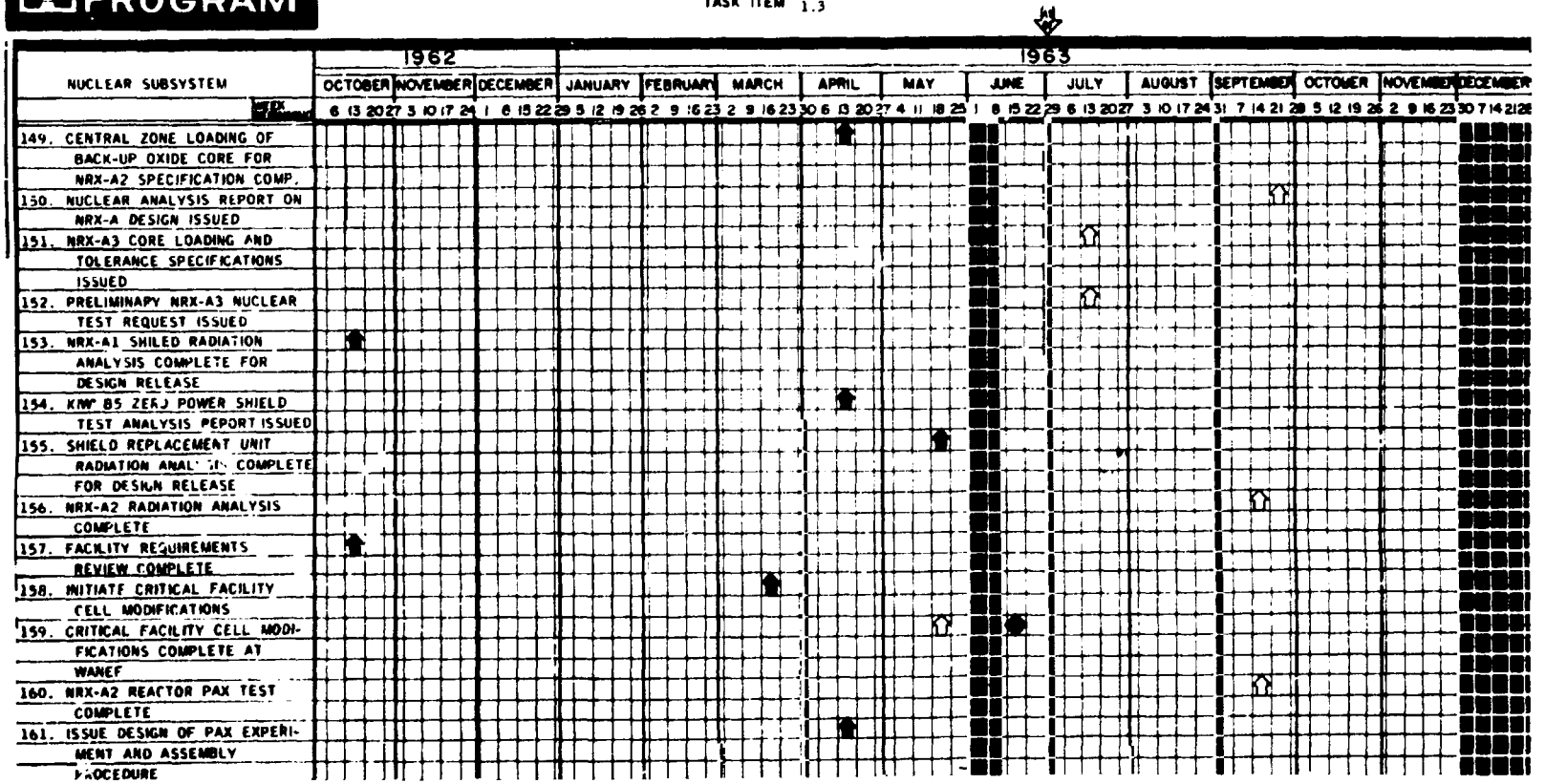
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 16 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
149. CENTRAL ZONE LOADING OF BACK-UP OXIDE CORE FOR NRX-A2 SPECIFICATION COMP.
150. NUCLEAR ANALYSIS REPORT ON NRX-A DESIGN ISSUED
151. NRX-A3 CORE LOADING AND TOLERANCE SPECIFICATIONS ISSUED
152. PRELIMINAPY NRX-A3 NUCLEAR TEST REQUEST ISSUED
153. NRX-A1 SHILED RADIATION ANALYSIS COMPLETE FOR DESIGN RELEASE
154. KIWI B5 ZERJ POWER SHIELD TEST ANALYSIS PEPORT ISSUED
155. SHIELD REPLACEMENT UNIT RADIATION ANAL' IS COMPLETE FOR DESIGN RELEASE
156. NRX-A2 RADIATION ANALYSIS COMPLETE
157. FACILITY REQUIREMENTS REVIEW COMPLETE
158. INITIATE CRITICAL FACILITY CELL MODIFICATIONS
159. CRITICAL FACILITY CELL MODIFICATIONS COMPLETE AT WANEF
160. NRX-A2 REACTOR PAX TEST COMPLETE
161. ISSUE DESIGN OF PAX EXPERIMENT AND ASSEMBLY PROCEDURE

DATE:

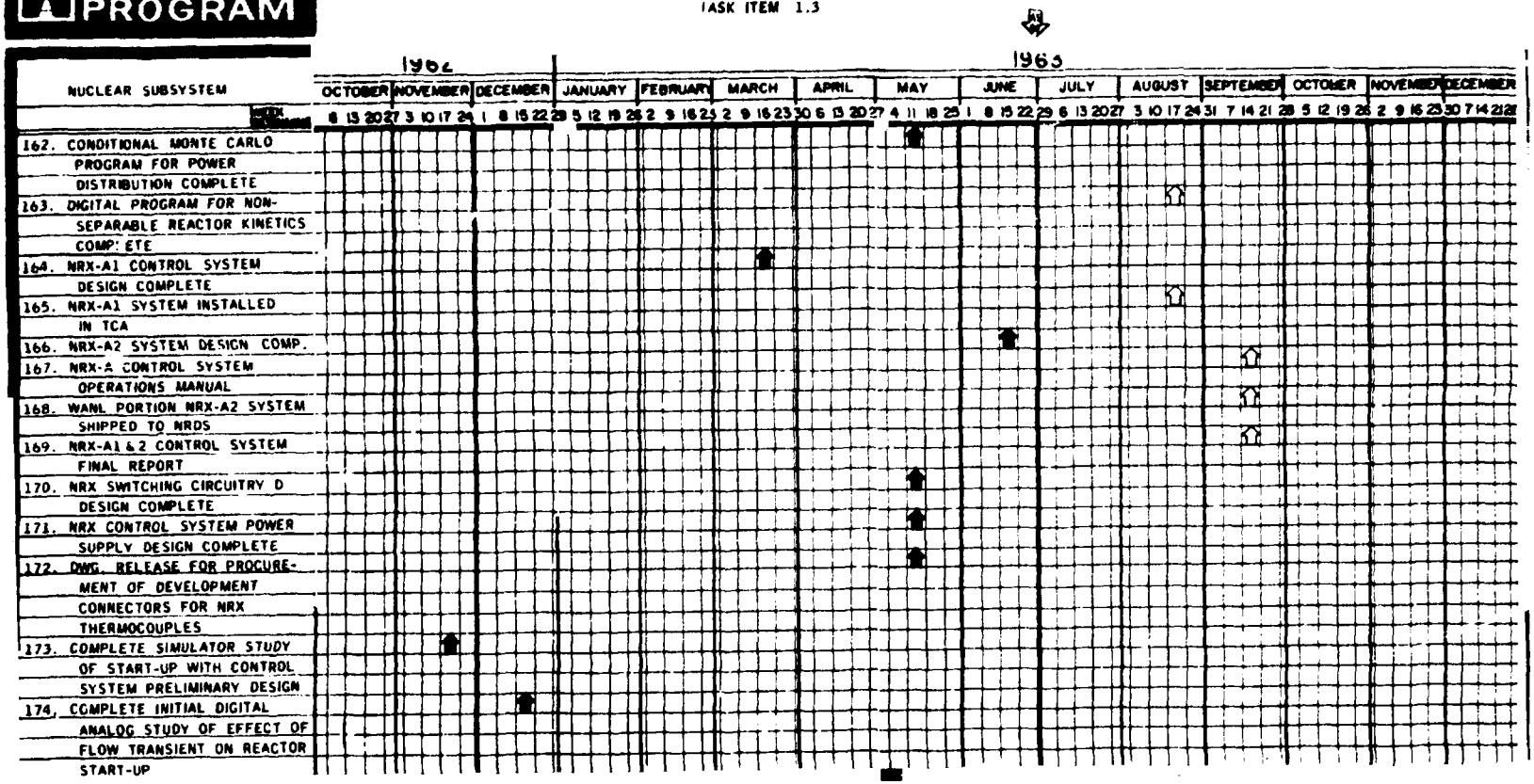
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 17 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
8 15 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
162. CONDITIONAL MONTE CARLO PROGRAM FOR POWER DISTRIBUTION COMPLETE
163. DIGITAL PROGRAM FOR NON-SEPARABLE REACTOR KINETICS COMPLETE
164. NRX-A1 CONTROL SYSTEM DESIGN COMPLETE
165. NRX-A1 SYSTEM INSTALLED IN TCA
166. NRX-A2 SYSTEM DESIGN COMP.
167. NRX-A CONTROL SYSTEM OPERATIONS MANUAL
168. WANL PORTION NRX-A2 SYSTEM SHIPPED TO NRDS
169. NRX-A1 & 2 CONTROL SYSTEM FINAL REPORT
170. NRX SWITCHING CIRCUITRY D DESIGN COMPLETE
171. NRX CONTROL SYSTEM POWER SUPPLY DESIGN COMPLETE
172. DWG. RELEASE FOR PROCUREMENT OF DEVELOPMENT CONNECTORS FOR NRX THERMOCOUPLES
173. COMPLETE SIMULATOR STUDY OF START-UP WITH CONTROL SYSTEM PRELIMINARY DESIGN
174. COMPLETE INITIAL DIGITAL ANALOG STUDY OF EFFECT OF FLOW TRANSIENT ON REACTOR START-UP

DATE:

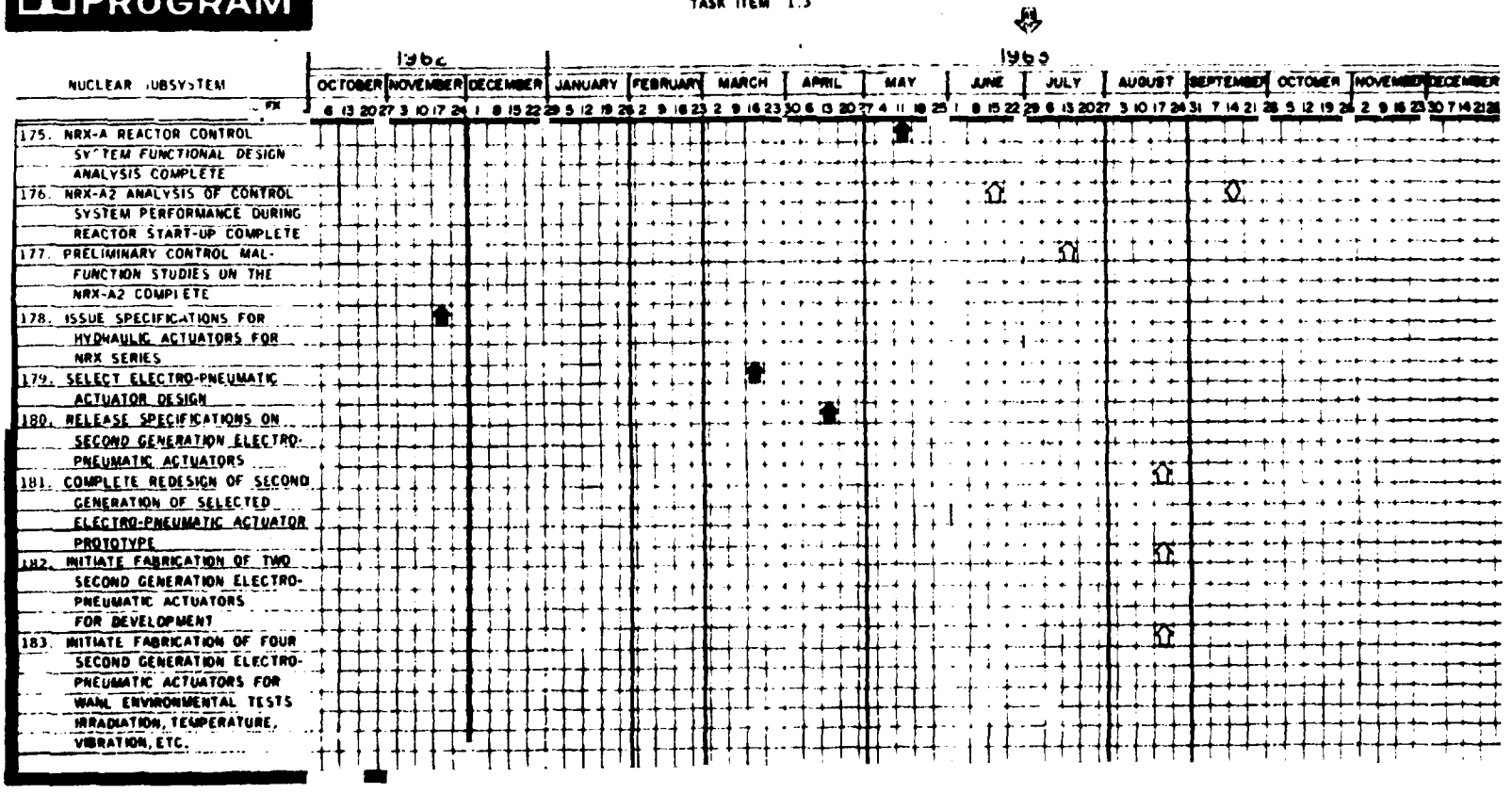
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 18 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER
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DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
175. NRX-A REACTOR CONTROL SYSTEM FUNCTIONAL DESIGN ANALYSIS COMPLETE
176. NRX-A2 ANALYSIS OF CONTROL SYSTEM PERFORMANCE DURING REACTOR START-UP COMPLETE
177. PRELIMINARY CONTROL MALFUNCTION STUDIES ON THE NRX-A2 COMPLETE
178. ISSUE SPECIFICATIONS FOR HYDRAULIC ACTUATORS FOR NRX SERIES
179. SELECT ELECTRO-PNEUMATIC ACTUATOR DESIGN
180. RELEASE SPECIFICATIONS ON SECOND GENERATION ELECTRO-PNEUMATIC ACTUATORS
181. COMPLETE REDESIGN OF SECOND GENERATION OF SELECTED ELECTRO-PNEUMATIC ACTUATOR PROTOTYPE
182. INITIATE FABRICATION OF TWO SECOND GENERATION ELECTRO-PNEUMATIC ACTUATORS FOR DEVELOPMENT
183. INITIATE FABRICATION OF FOUR SECOND GENERATION ELECTRO-PNEUMATIC ACTUATORS FOR WANL ENVIRONMENTAL TESTS IRRADIATION, TEMPERATURE, VIBRATION, ETC.

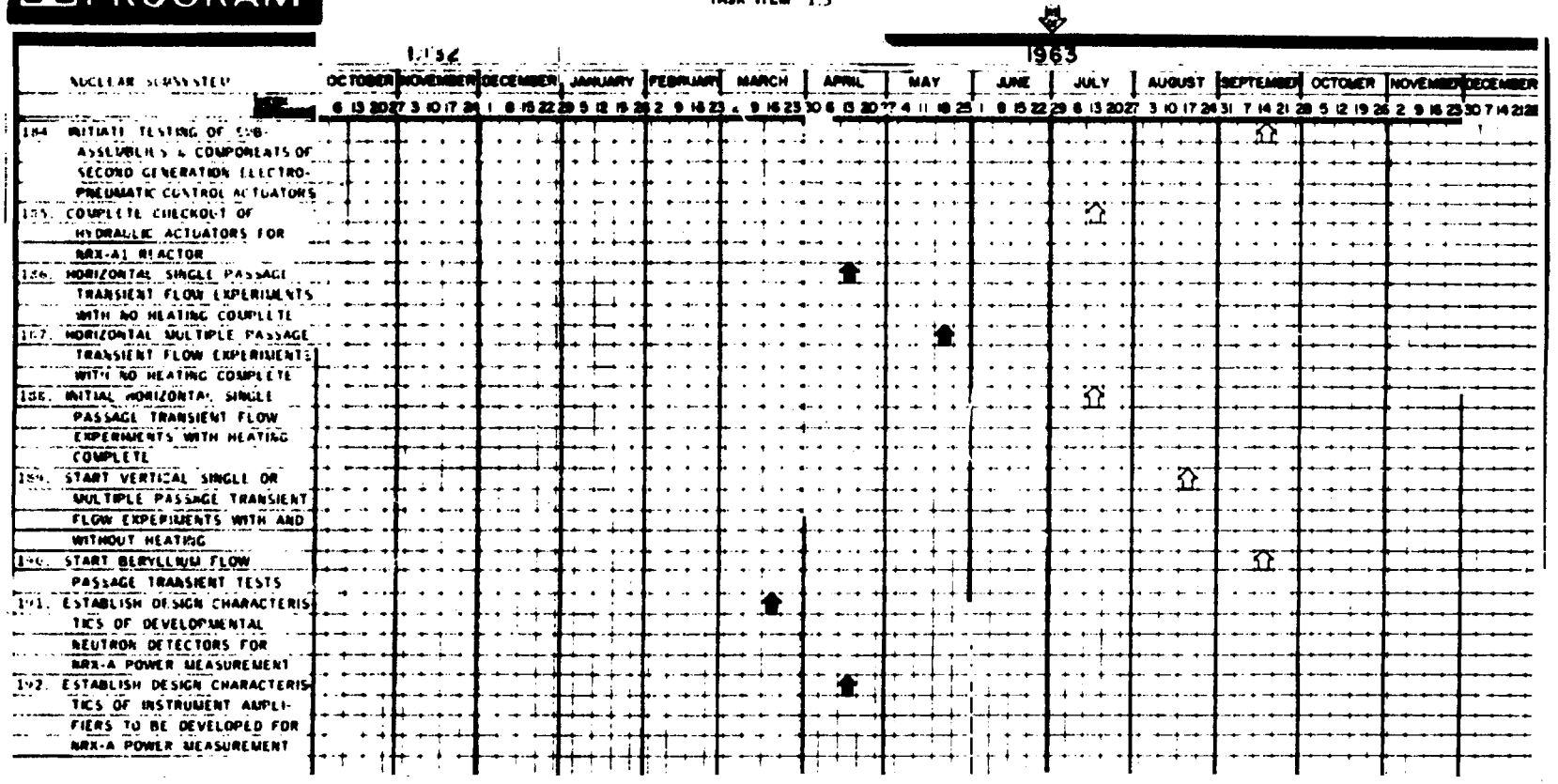
DATE:

SCHEDULED MILESTONE
MILESTONE ACHIEVEMENT
RESCHEDULED MILESTONE
RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER
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DECEMBER
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FEBRUARY
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APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
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NOVEMBER
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6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
NUCLEAR SUBSYSTEM
134. INITIATE TESTING OF SUB-ASSEMBLIES & COMPONENTS OF SECOND GENERATION ELECTRO-PNEUMATIC CONTROL ACTUATORS
135. COMPLETE CHECKOUT OF HYDRAULIC ACTUATORS FOR NRX-A1 REACTOR
136. HORIZONTAL SINGLE PASSAGE TRANSIENT FLOW EXPERIMENTS WITH NO HEATING COMPLETE
137. HORIZONTAL MULTIPLE PASSAGE TRANSIENT FLOW EXPERIMENTS WITH NO HEATING COMPLETE
138. INITIAL HORIZONTAL SINGLE PASSAGE TRANSIENT FLOW EXPERIMENTS WITH HEATING COMPLETE
139. START VERTICAL SINGLE OR MULTIPLE PASSAGE TRANSIENT FLOW EXPERIMENTS WITH AND WITHOUT HEATING
140. START BERYLLIUM FLOW PASSAGE TRANSIENT TESTS
141. ESTABLISH DESIGN CHARACTERISTICS OF DEVELOPMENTAL NEUTRON DETECTORS FOR NRX-A POWER MEASUREMENT
142. ESTABLISH DESIGN CHARACTERISTICS OF INSTRUMENT AMPLIFIERS TO BE DEVELOPED FOR NRX-A POWER MEASUREMENT

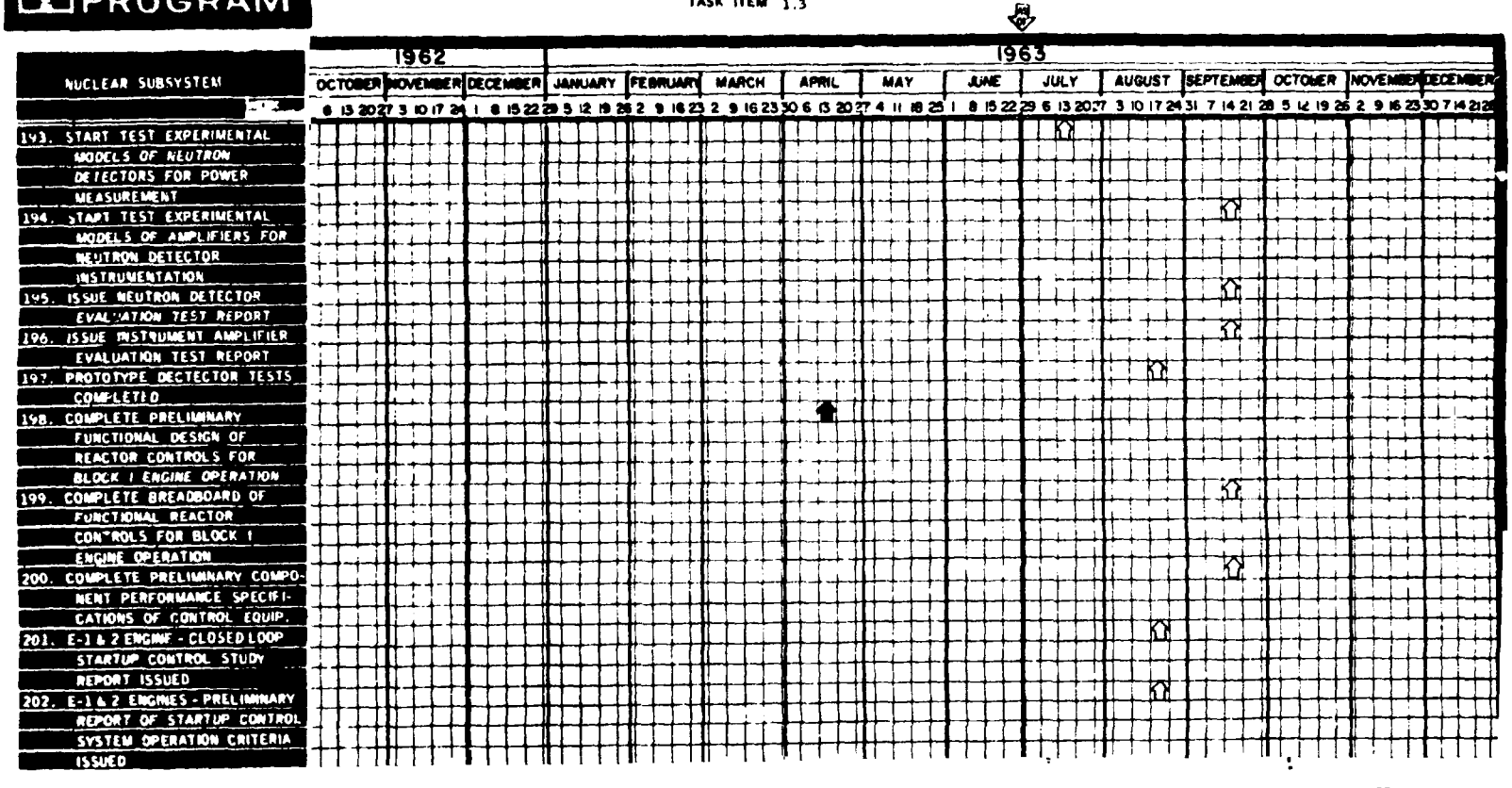
DATE:

⌂ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
NUCLEAR SUBSYSTEM
143. START TEST EXPERIMENTAL MODELS OF NEUTRON DETECTORS FOR POWER MEASUREMENT
144. START TEST EXPERIMENTAL MODELS OF AMPLIFIERS FOR NEUTRON DETECTOR INSTRUMENTATION
145. ISSUE NEUTRON DETECTOR EVALUATION TEST REPORT
146. ISSUE INSTRUMENT AMPLIFIER EVALUATION TEST REPORT
147. PROTOTYPE DECTECTOR TESTS COMPLETED
148. COMPLETE PRELIMINARY FUNCTIONAL DESIGN OF REACTOR CONTROLS FOR BLOCK I ENGINE OPERATION
149. COMPLETE BREADBOARD OF FUNCTIONAL REACTOR CONTROLS FOR BLOCK I ENGINE OPERATION
200. COMPLETE PRELIMINARY COMPONENT PERFORMANCE SPECIFICATIONS OF CONTROL EQUIP.
201. E-1 & 2 ENGINE - CLOSED LOOP STARTUP CONTROL STUDY REPORT ISSUED
202. E-1 & 2 ENGINES - PRELIMINARY REPORT OF STARTUP CONTROL SYSTEM OPERATION CRITERIA ISSUED

DATE:

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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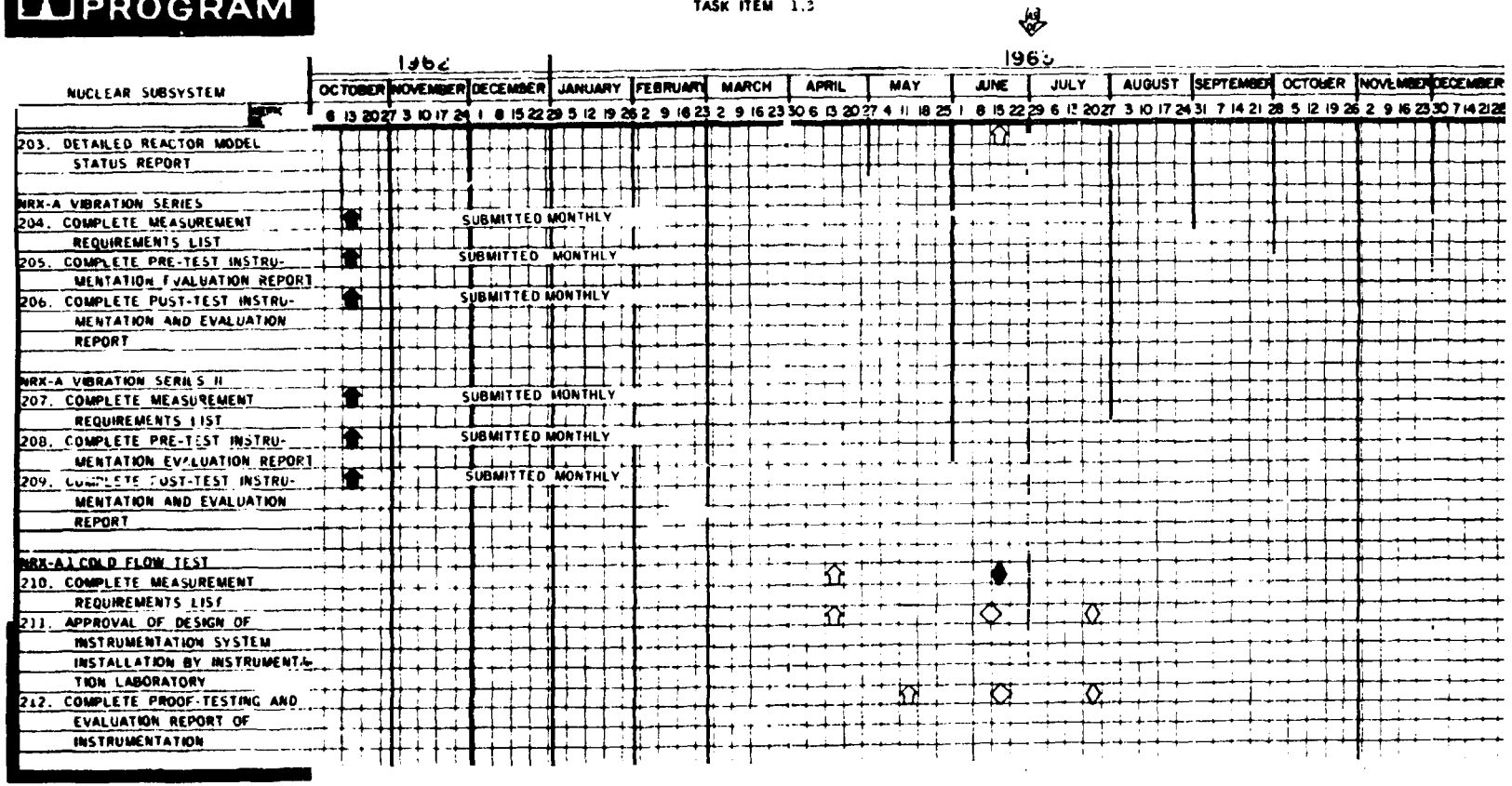
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
NUCLEAR SUBSYSTEM
203. DETAILED REACTOR MODEL STATUS REPORT
NRX-A VIBRATION SERIES
204. COMPLETE MEASUREMENT REQUIREMENTS LIST
SUBMITTED MONTHLY
205. COMPLETE PRE-TEST INSTRUMENTATION EVALUATION REPORT
SUBMITTED MONTHLY
206. COMPLETE POST-TEST INSTRUMENTATION AND EVALUATION REPORT
SUBMITTED MONTHLY
NRX-A VIBRATION SERIES II
207. COMPLETE MEASUREMENT REQUIREMENTS LIST
SUBMITTED MONTHLY
208. COMPLETE PRE-TEST INSTRUMENTATION EVALUATION REPORT
SUBMITTED MONTHLY
209. COMPLETE POST-TEST INSTRUMENTATION AND EVALUATION REPORT
SUBMITTED MONTHLY
NRX-A3 COLD FLOW TEST
210. COMPLETE MEASUREMENT REQUIREMENTS LIST
211. APPROVAL OF DESIGN OF INSTRUMENTATION SYSTEM INSTALLATION BY INSTRUMENTATION LABORATORY
212. COMPLETE PROOF-TESTING AND EVALUATION REPORT OF INSTRUMENTATION

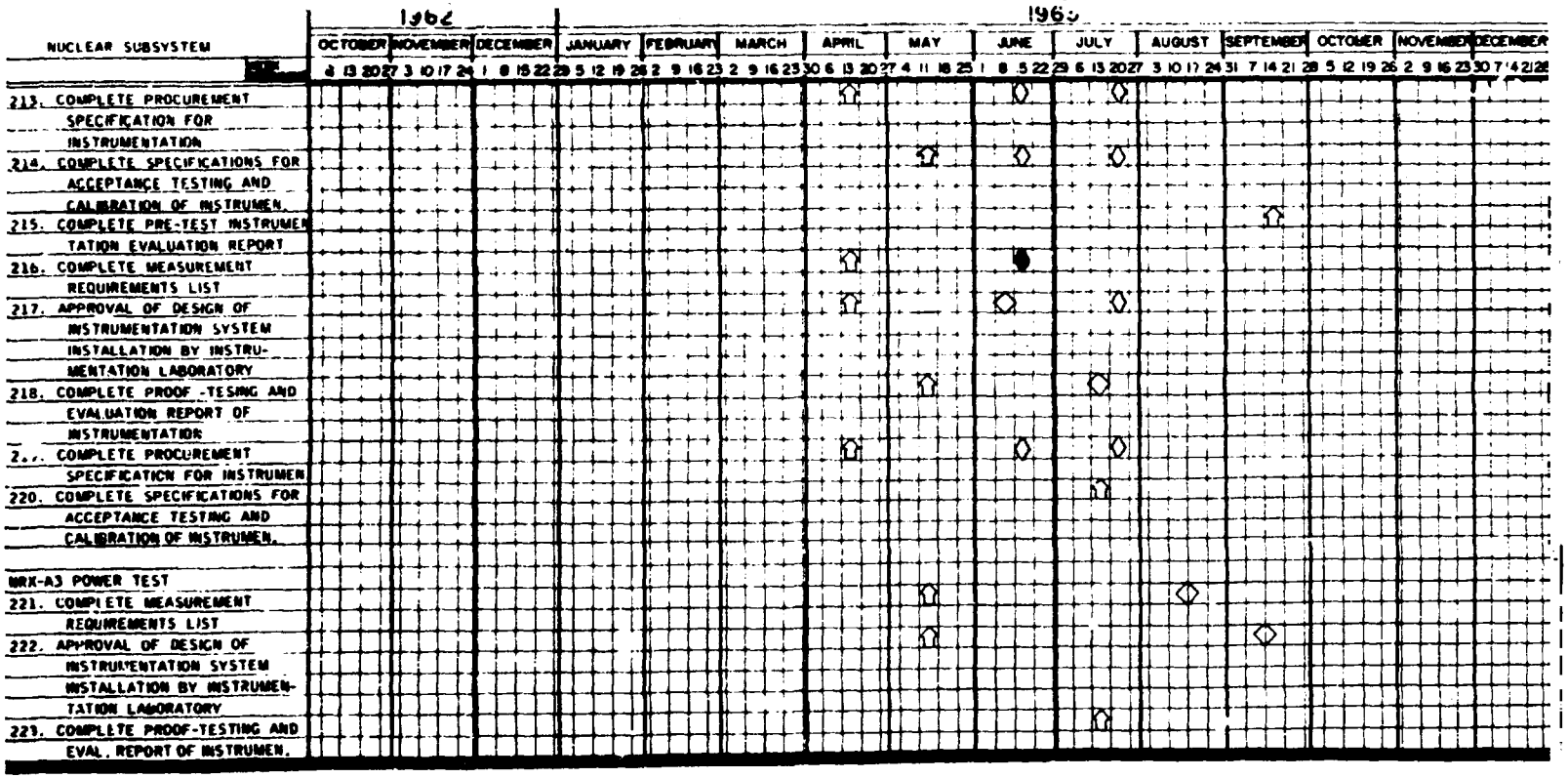
DATE:

- SCHEDULED MILESTONE
- MILESTONE ACHIEVEMENT
- RESCHEDULED MILESTONE
- RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
213. COMPLETE PROCUREMENT SPECIFICATION FOR INSTRUMENTATION
214. COMPLETE SPECIFICATIONS FOR ACCEPTANCE TESTING AND CALIBRATION OF INSTRUMEN.
215. COMPLETE PRE-TEST INSTRUMENTATION EVALUATION REPORT
216. COMPLETE MEASUREMENT REQUIREMENTS LIST
217. APPROVAL OF DESIGN OF INSTRUMENTATION SYSTEM INSTALLATION BY INSTRUMENTATION LABORATORY
218. COMPLETE PROOF-TESING AND EVALUATION REPORT OF INSTRUMENTATION
2.. COMPLETE PROCUREMENT SPECIFICATION FOR INSTRUMEN
220. COMPLETE SPECIFICATIONS FOR ACCEPTANCE TESTING AND CALIBRATION OF INSTRUMEN.
NRX-A3 POWER TEST
221. COMPLETE MEASUREMENT REQUIREMENTS LIST
222. APPROVAL OF DESIGN OF INSTRUMENTATION SYSTEM INSTALLATION BY INSTRUMENTATION LABORATORY
223. COMPLETE PROOF-TESTING AND EVAL. REPORT OF INSTRUMEN.

DATE:

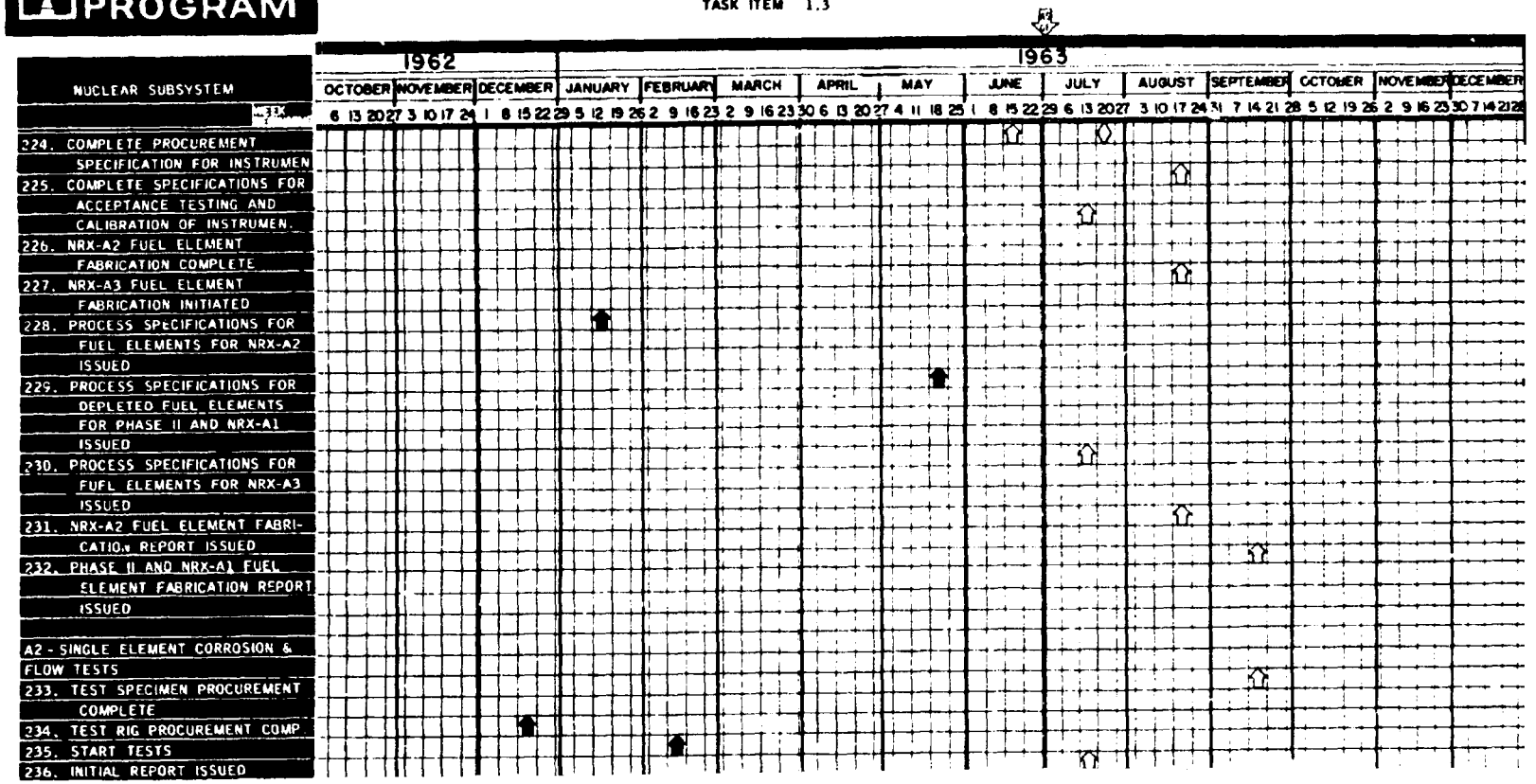
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 23 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
NUCLEAR SUBSYSTEM
224. COMPLETE PROCUREMENT SPECIFICATION FOR INSTRUMEN
225. COMPLETE SPECIFICATIONS FOR ACCEPTANCE TESTING AND CALIBRATION OF INSTRUMEN.
226. NRX-A2 FUEL ELEMENT FABRICATION COMPLETE
227. NRX-A3 FUEL ELEMENT FABRICATION INITIATED
228. PROCESS SPECIFICATIONS FOR FUEL ELEMENTS FOR NRX-A2 ISSUED
229. PROCESS SPECIFICATIONS FOR DEPLETED FUEL ELEMENTS FOR PHASE II AND NRX-A1 ISSUED
230. PROCESS SPECIFICATIONS FOR FUEL ELEMENTS FOR NRX-A3 ISSUED
231. NRX-A2 FUEL ELEMENT FABRICATION REPORT ISSUED
232. PHASE II AND NRX-A1 FUEL ELEMENT FABRICATION REPORT ISSUED
A2 - SINGLE ELEMENT CORROSION & FLOW TESTS
233. TEST SPECIMEN PROCUREMENT COMPLETE
234. TEST RIG PROCUREMENT COMP
235. START TESTS
236. INITIAL REPORT ISSUED

DATE:

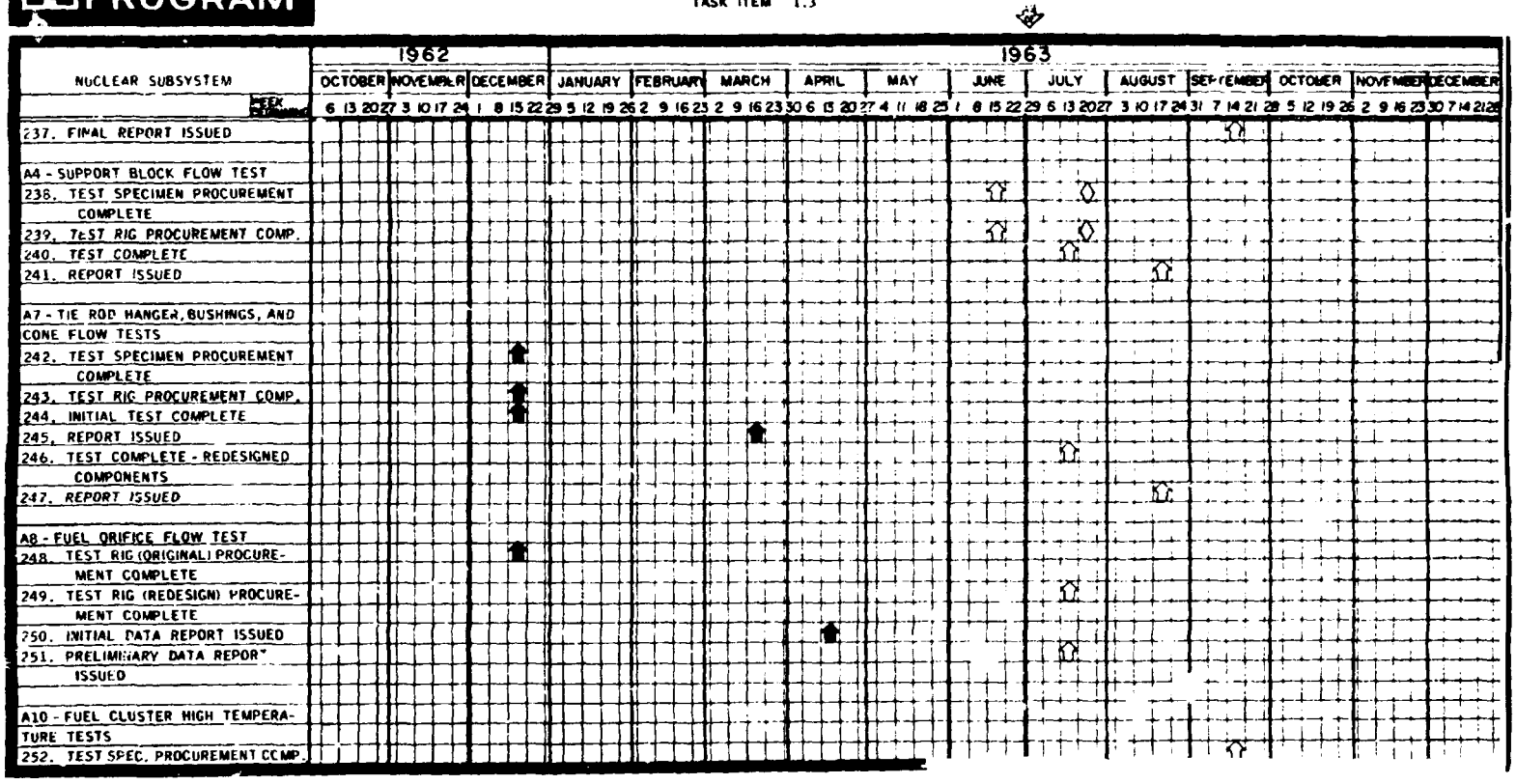
- ⇧ SCHEDULED MILESTONE
- ◇ RESCHEDULED MILESTONE
- ⬆ MILESTONE ACHIEVEMENT
- ◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 24 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
WEEK BEGINNING
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
237. FINAL REPORT ISSUED
A4 - SUPPORT BLOCK FLOW TEST
238. TEST SPECIMEN PROCUREMENT COMPLETE
239. TEST RIG PROCUREMENT COMP.
240. TEST COMPLETE
241. REPORT ISSUED
A7 - TIE ROD HANGER, BUSHINGS, AND CONE FLOW TESTS
242. TEST SPECIMEN PROCUREMENT COMPLETE
243. TEST RIG PROCUREMENT COMP.
244. INITIAL TEST COMPLETE
245. REPORT ISSUED
246. TEST COMPLETE - REDESIGNED COMPONENTS
247. REPORT ISSUED
A8 - FUEL ORIFICE FLOW TEST
248. TEST RIG (ORIGINAL) PROCUREMENT COMPLETE
249. TEST RIG (REDESIGN) PROCUREMENT COMPLETE
250. INITIAL DATA REPORT ISSUED
251. PRELIMINARY DATA REPORT ISSUED
A10 - FUEL CLUSTER HIGH TEMPERATURE TESTS
252. TEST SPEC. PROCUREMENT COMP.

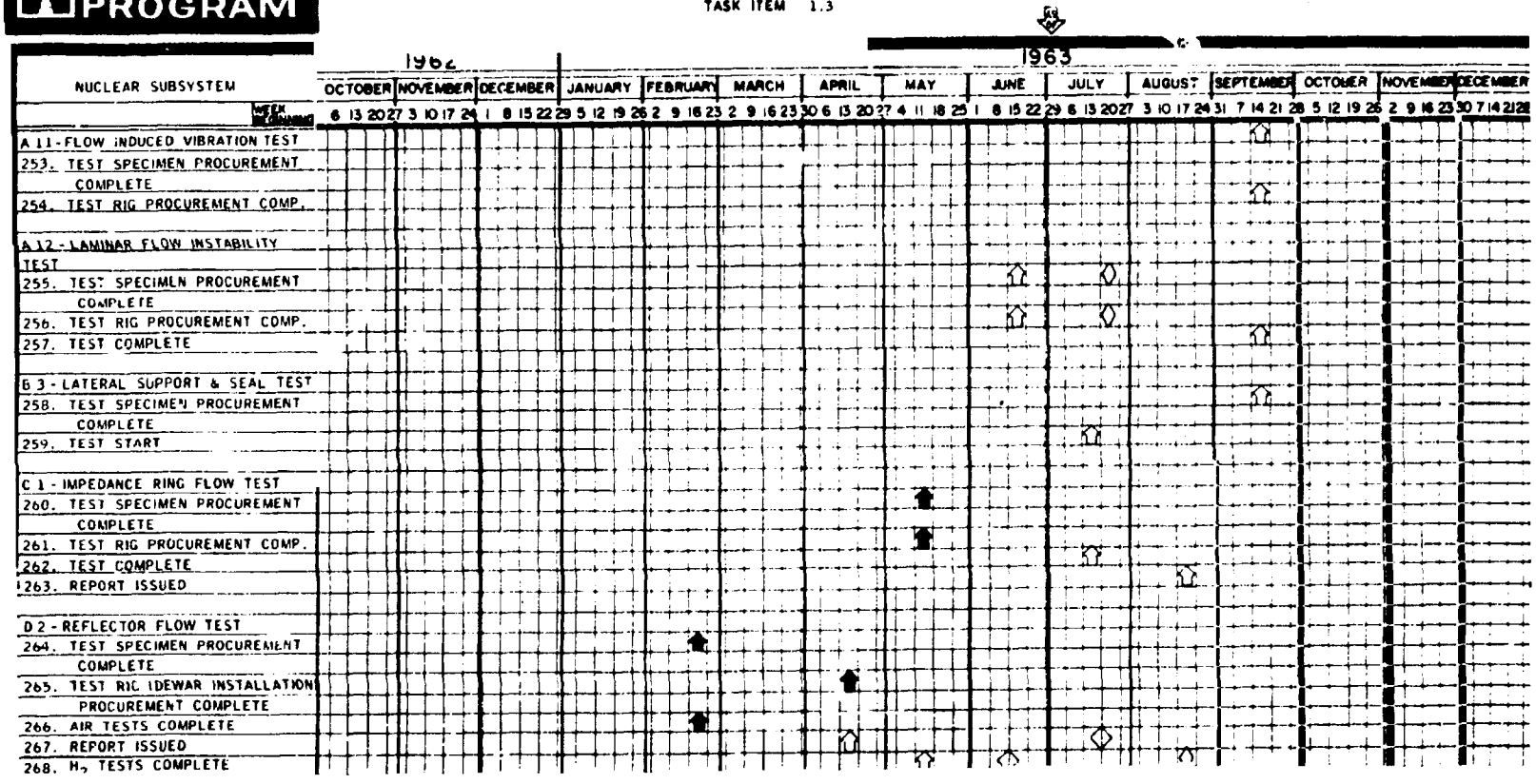
DATE:

- SCHEDULED MILESTONE
- RESCHEDULED MILESTONE
- MILESTONE ACHIEVEMENT
- RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
WEEK BEGINNING
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
A 11 - FLOW INDUCED VIBRATION TEST
253. TEST SPECIMEN PROCUREMENT COMPLETE
254. TEST RIG PROCUREMENT COMP.
A 12 - LAMINAR FLOW INSTABILITY TEST
255. TEST SPECIMEN PROCUREMENT COMPLETE
256. TEST RIG PROCUREMENT COMP.
257. TEST COMPLETE
B 3 - LATERAL SUPPORT & SEAL TEST
258. TEST SPECIMEN PROCUREMENT COMPLETE
259. TEST START
C 1 - IMPEDANCE RING FLOW TEST
260. TEST SPECIMEN PROCUREMENT COMPLETE
261. TEST RIG PROCUREMENT COMP.
262. TEST COMPLETE
263. REPORT ISSUED
D 2 - REFLECTOR FLOW TEST
264. TEST SPECIMEN PROCUREMENT COMPLETE
265. TEST RIG DEWAR INSTALLATION PROCUREMENT COMPLETE
266. AIR TESTS COMPLETE
267. REPORT ISSUED
268. H_2 TESTS COMPLETE

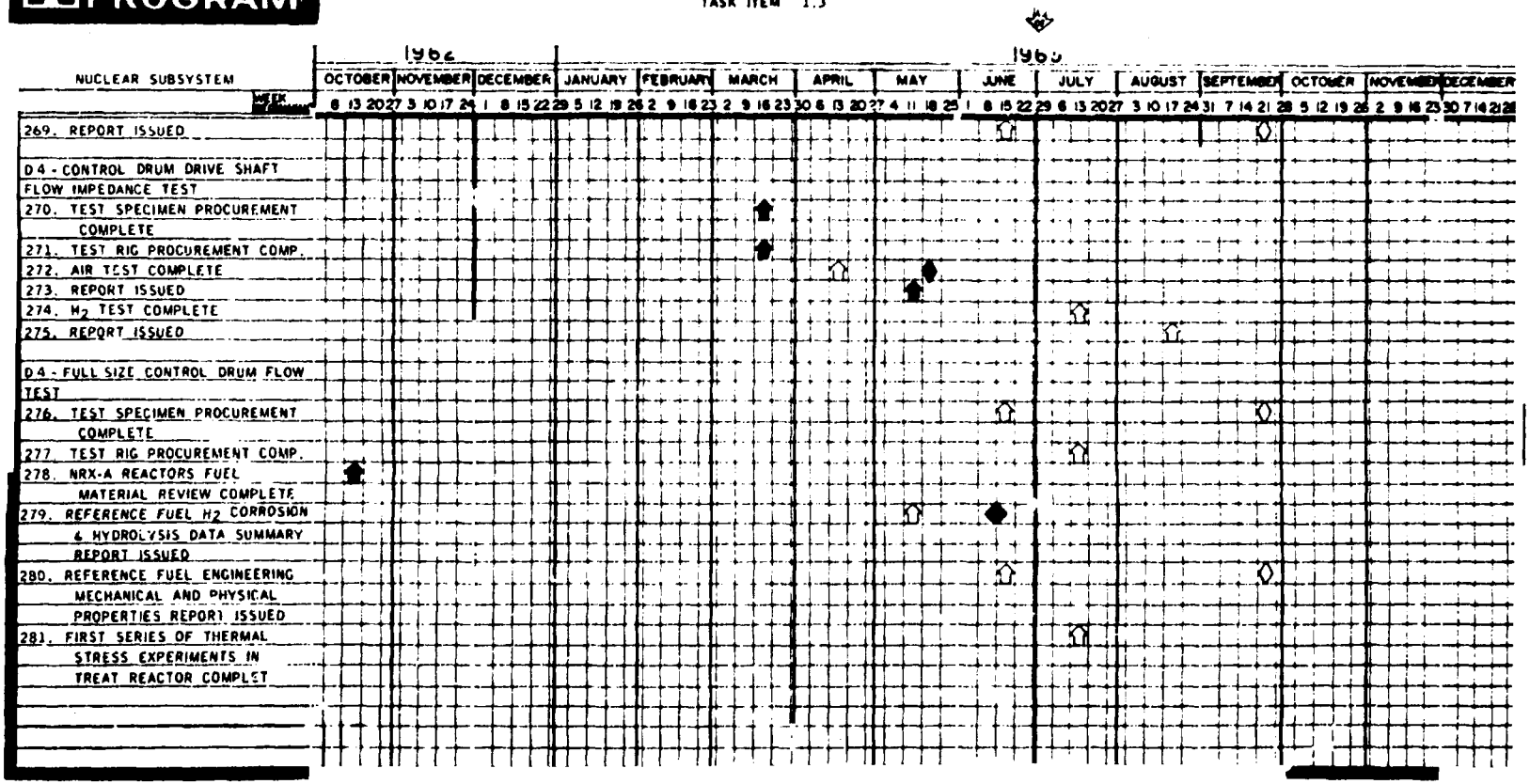
DATE:

- ⇧ SCHEDULED MILESTONE
- ⇧ MILESTONE ACHIEVEMENT
- ◇ RESCHEDULED MILESTONE
- ◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK
8 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
269. REPORT ISSUED
D4 - CONTROL DRUM DRIVE SHAFT FLOW IMPEDANCE TEST
270. TEST SPECIMEN PROCUREMENT COMPLETE
271. TEST RIG PROCUREMENT COMP.
272. AIR TEST COMPLETE
273. REPORT ISSUED
274. H_2 TEST COMPLETE
275. REPORT ISSUED
D4 - FULL SIZE CONTROL DRUM FLOW TEST
276. TEST SPECIMEN PROCUREMENT COMPLETE
277. TEST RIG PROCUREMENT COMP.
278. NRX-A REACTORS FUEL MATERIAL REVIEW COMPLETE
279. REFERENCE FUEL H_2 CORROSION & HYDROLYSIS DATA SUMMARY REPORT ISSUED
280. REFERENCE FUEL ENGINEERING MECHANICAL AND PHYSICAL PROPERTIES REPORT ISSUED
281. FIRST SERIES OF THERMAL STRESS EXPERIMENTS IN TREAT REACTOR COMPLET

DATE:

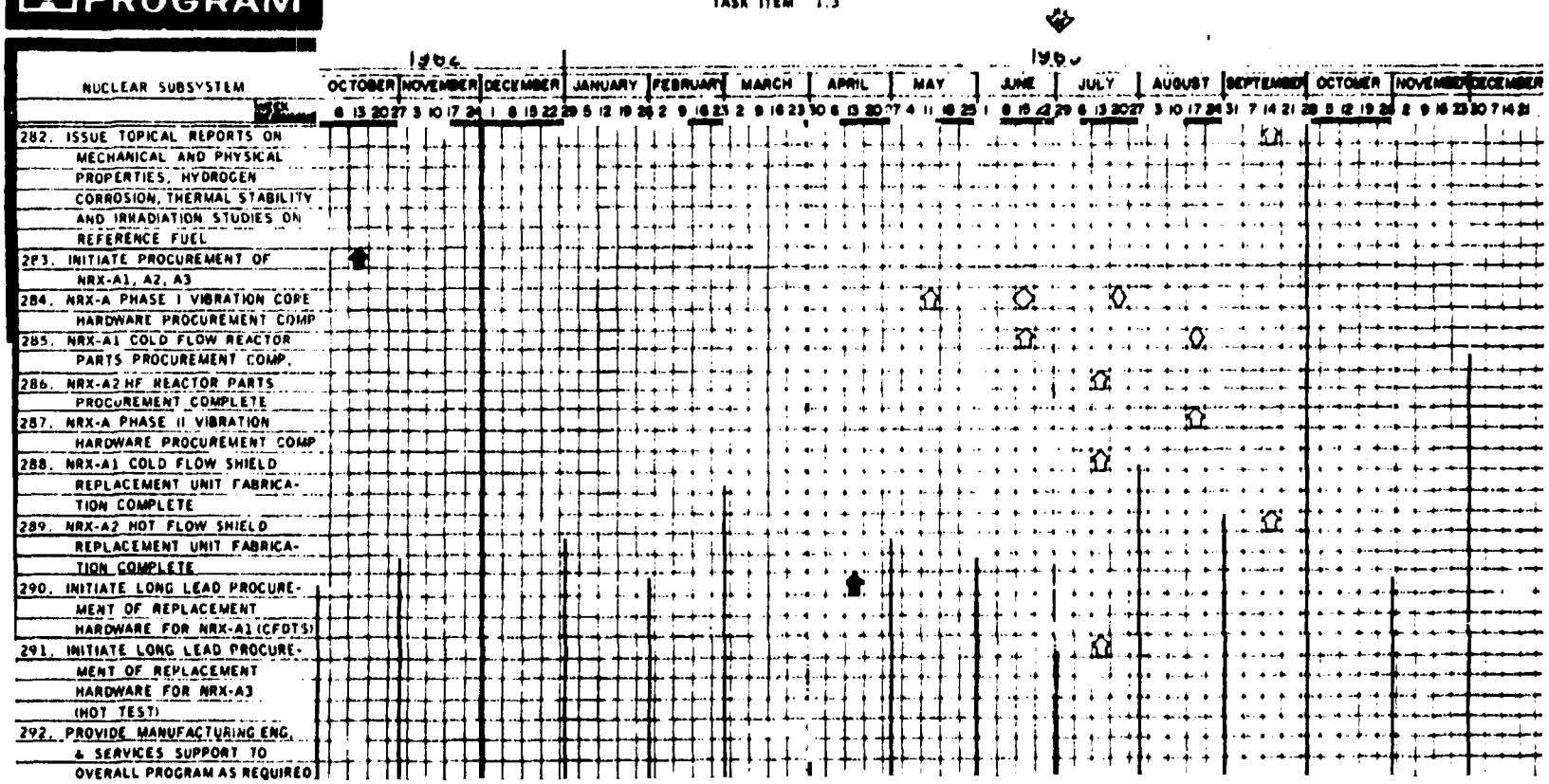
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 27 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
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MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
282. ISSUE TOPICAL REPORTS ON MECHANICAL AND PHYSICAL PROPERTIES, HYDROGEN CORROSION, THERMAL STABILITY AND IRRADIATION STUDIES ON REFERENCE FUEL
283. INITIATE PROCUREMENT OF NRX-A1, A2, A3
284. NRX-A PHASE I VIBRATION CORE HARDWARE PROCUREMENT COMP
285. NRX-A1 COLD FLOW REACTOR PARTS PROCUREMENT COMP.
286. NRX-A2 HF REACTOR PARTS PROCUREMENT COMPLETE
287. NRX-A PHASE II VIBRATION HARDWARE PROCUREMENT COMP
288. NRX-A1 COLD FLOW SHIELD REPLACEMENT UNIT FABRICATION COMPLETE
289. NRX-A2 HOT FLOW SHIELD REPLACEMENT UNIT FABRICATION COMPLETE
290. INITIATE LONG LEAD PROCUREMENT OF REPLACEMENT HARDWARE FOR NRX-A1 (CFDTS)
291. INITIATE LONG LEAD PROCUREMENT OF REPLACEMENT HARDWARE FOR NRX-A3 (HOT TEST)
292. PROVIDE MANUFACTURING ENG. & SERVICES SUPPORT TO OVERALL PROGRAM AS REQUIRED

DATE:

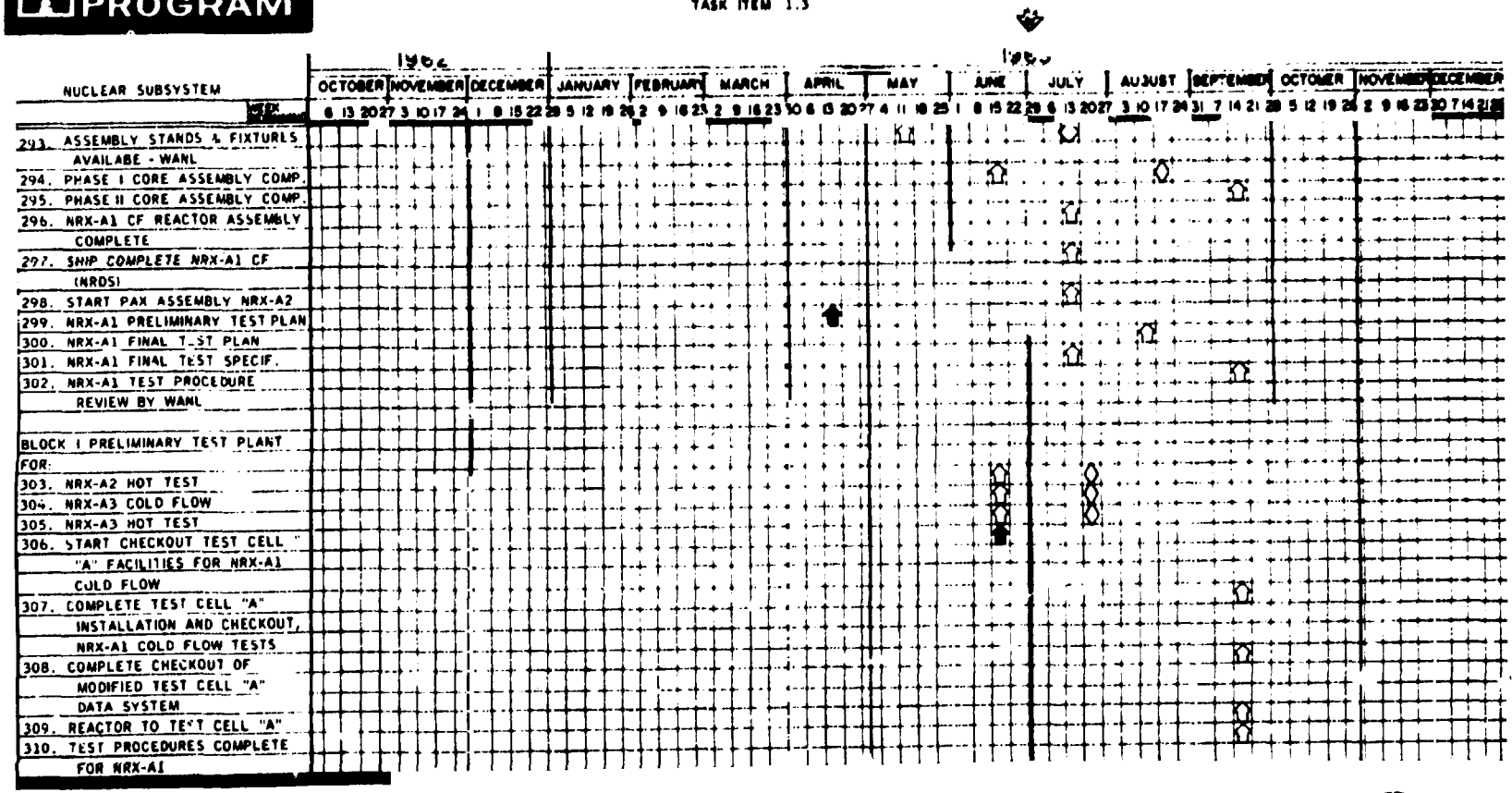
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 28 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
NUCLEAR SUBSYSTEM
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
293. ASSEMBLY STANDS & FIXTURES AVAILABE - WANL
294. PHASE I CORE ASSEMBLY COMP.
295. PHASE II CORE ASSEMBLY COMP.
296. NRX-A1 CF REACTOR ASSEMBLY COMPLETE
297. SHIP COMPLETE NRX-A1 CF (NRDS)
298. START PAX ASSEMBLY NRX-A2
299. NRX-A1 PRELIMINARY TEST PLAN
300. NRX-A1 FINAL TEST PLAN
301. NRX-A1 FINAL TEST SPECIF.
302. NRX-A1 TEST PROCEDURE REVIEW BY WANL
BLOCK I PRELIMINARY TEST PLANT FOR:
303. NRX-A2 HOT TEST
304. NRX-A3 COLD FLOW
305. NRX-A3 HOT TEST
306. START CHECKOUT TEST CELL "A" FACILITIES FOR NRX-A1 COLD FLOW
307. COMPLETE TEST CELL "A" INSTALLATION AND CHECKOUT, NRX-A1 COLD FLOW TESTS
308. COMPLETE CHECKOUT OF MODIFIED TEST CELL "A" DATA SYSTEM
309. REACTOR TO TEST CELL "A"
310. TEST PROCEDURES COMPLETE FOR NRX-A1

DATE:

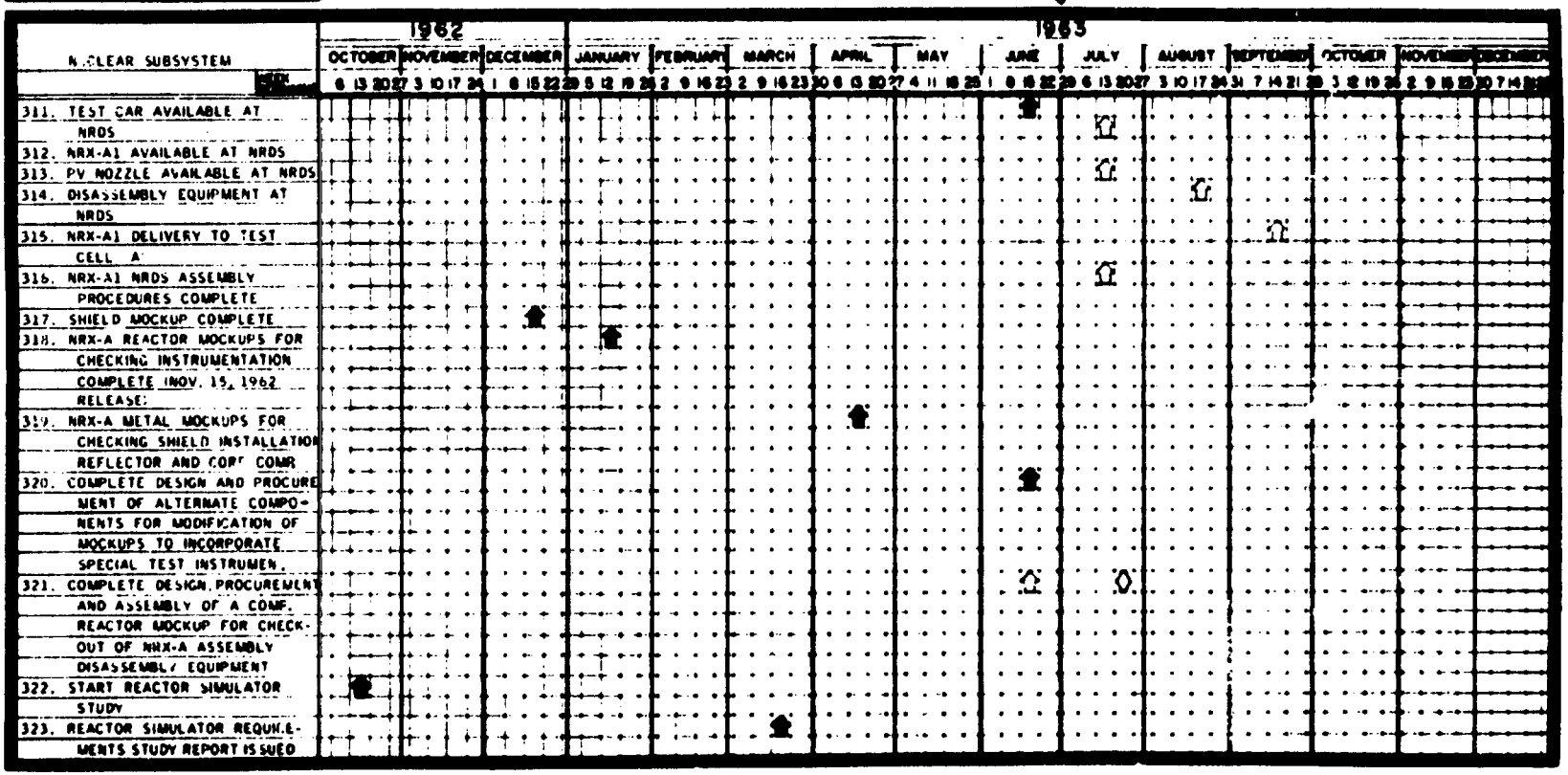
⌂ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 29 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.3


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
NUCLEAR SUBSYSTEM
WEEK
311. TEST CAR AVAILABLE AT NRDS
312. NRX-A1 AVAILABLE AT NRDS
313. PV NOZZLE AVAILABLE AT NRDS
314. DISASSEMBLY EQUIPMENT AT NRDS
315. NRX-A1 DELIVERY TO TEST CELL A
316. NRX-A1 NRDS ASSEMBLY PROCEDURES COMPLETE
317. SHIELD MOCKUP COMPLETE
318. NRX-A REACTOR MOCKUPS FOR CHECKING INSTRUMENTATION COMPLETE (NOV. 15, 1962 RELEASE)
319. NRX-A METAL MOCKUPS FOR CHECKING SHIELD INSTALLATION REFLECTOR AND CORE COMP
320. COMPLETE DESIGN AND PROCUREMENT OF ALTERNATE COMPONENTS FOR MODIFICATION OF MOCKUPS TO INCORPORATE SPECIAL TEST INSTRUMEN.
321. COMPLETE DESIGN, PROCUREMENT AND ASSEMBLY OF A CONF. REACTOR MOCKUP FOR CHECK-OUT OF NRX-A ASSEMBLY DISASSEMBLY EQUIPMENT
322. START REACTOR SIMULATOR STUDY
323. REACTOR SIMULATOR REQUIREMENTS STUDY REPORT ISSUED

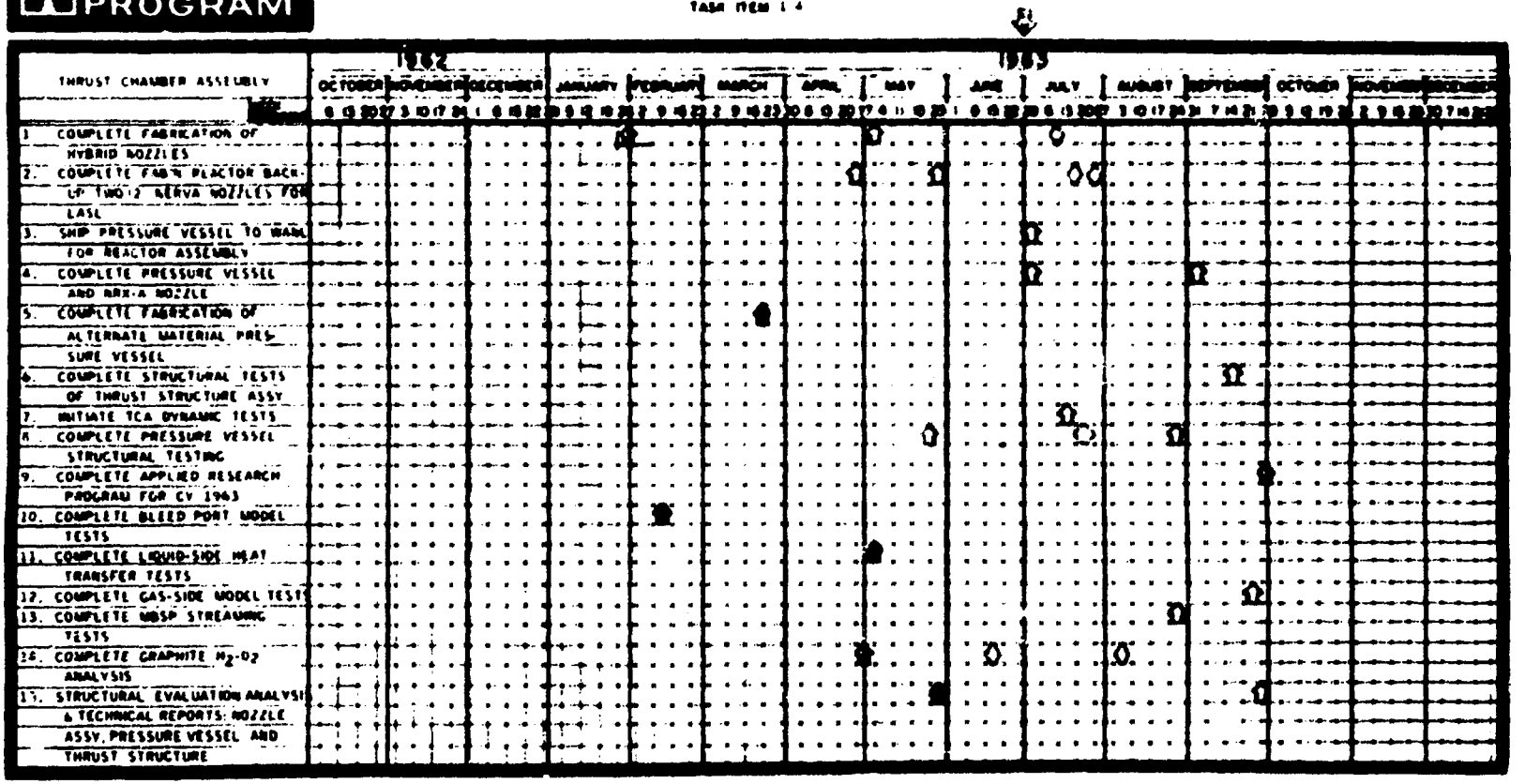
DATE:

⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.4



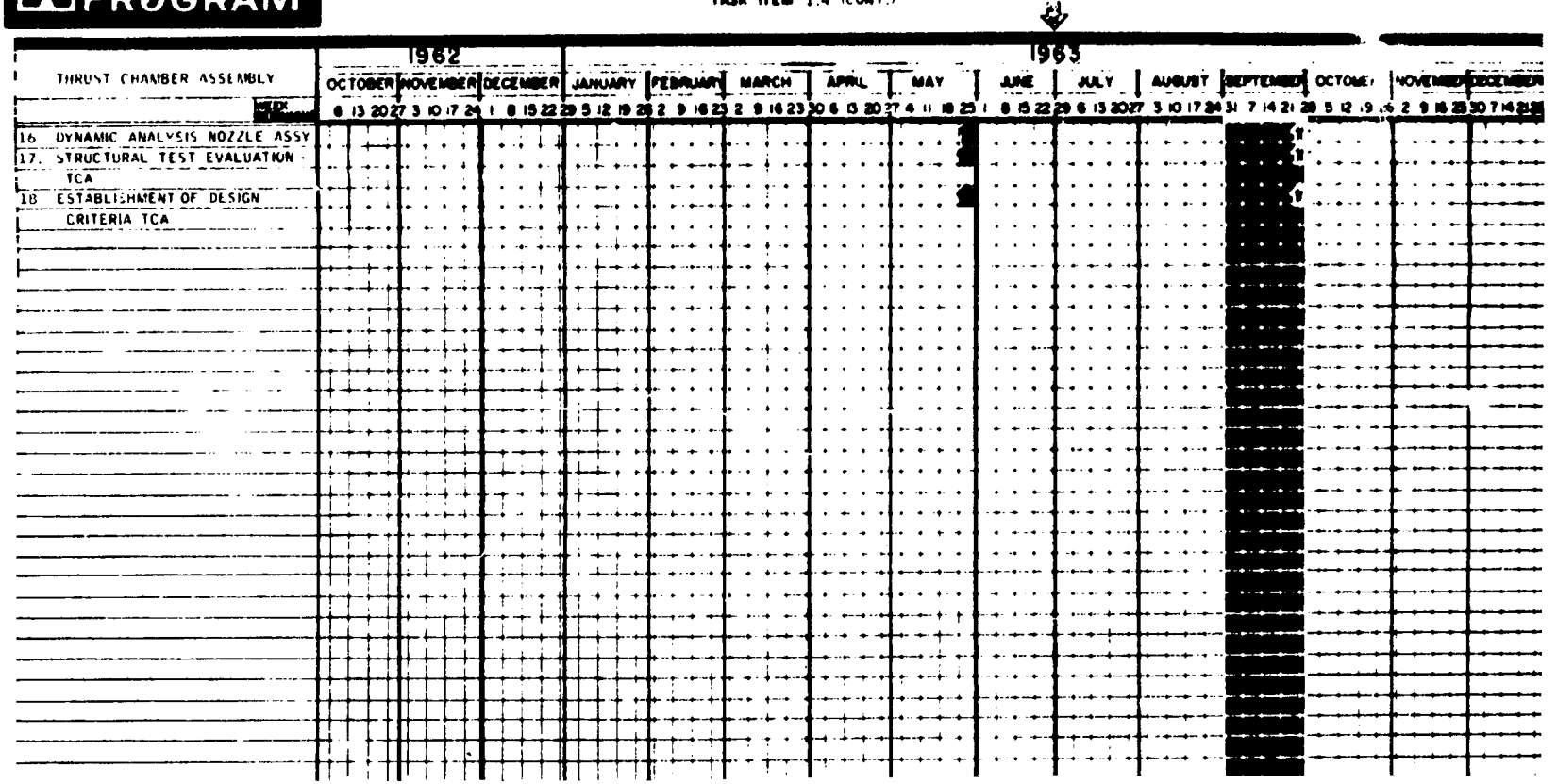
◇ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 31 of 61

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.4 (CONT.)



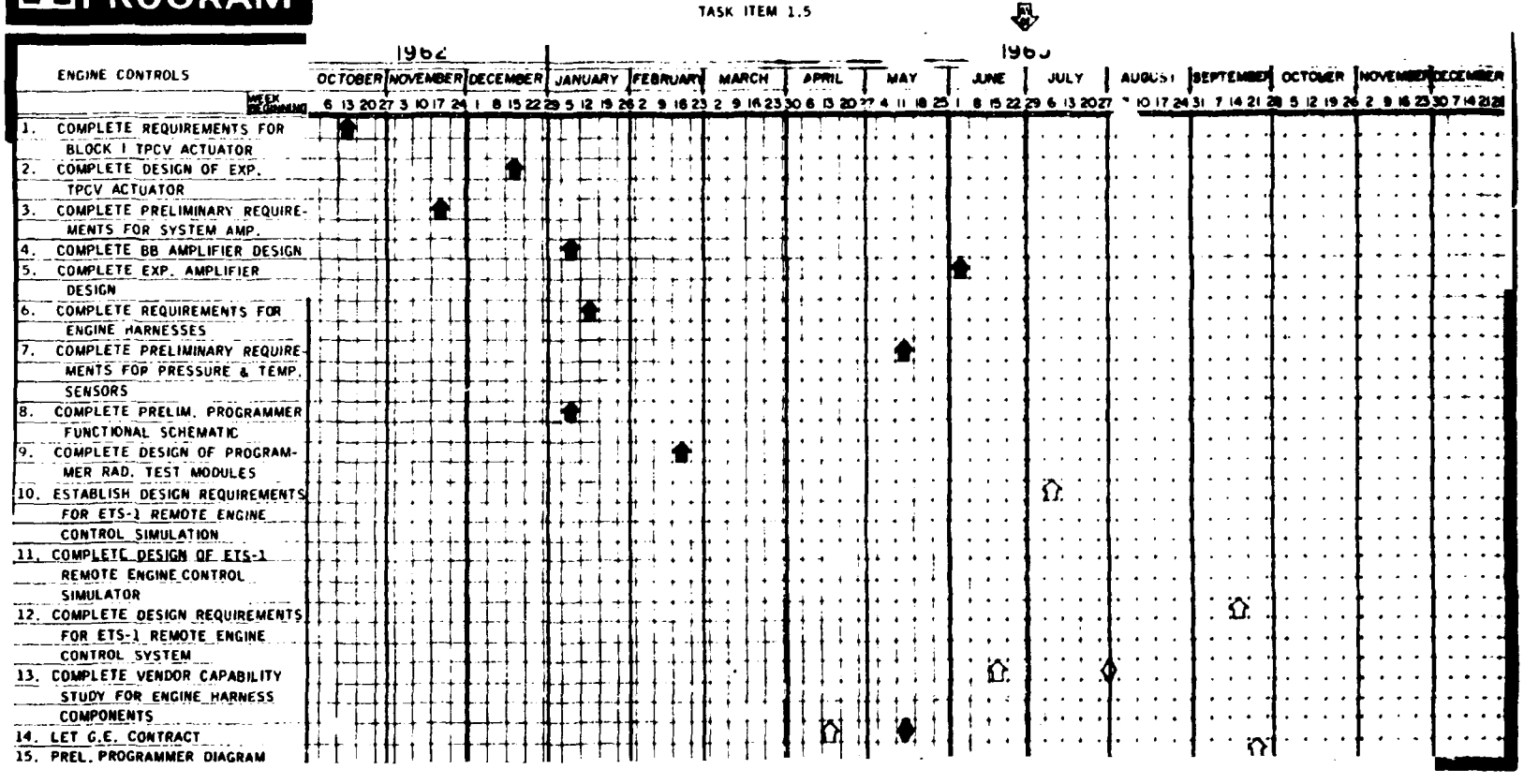
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

CONFIDENTIAL

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.5


1962
1963
ENGINE CONTROLS
WEEK BEGINNING
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
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SEPTEMBER
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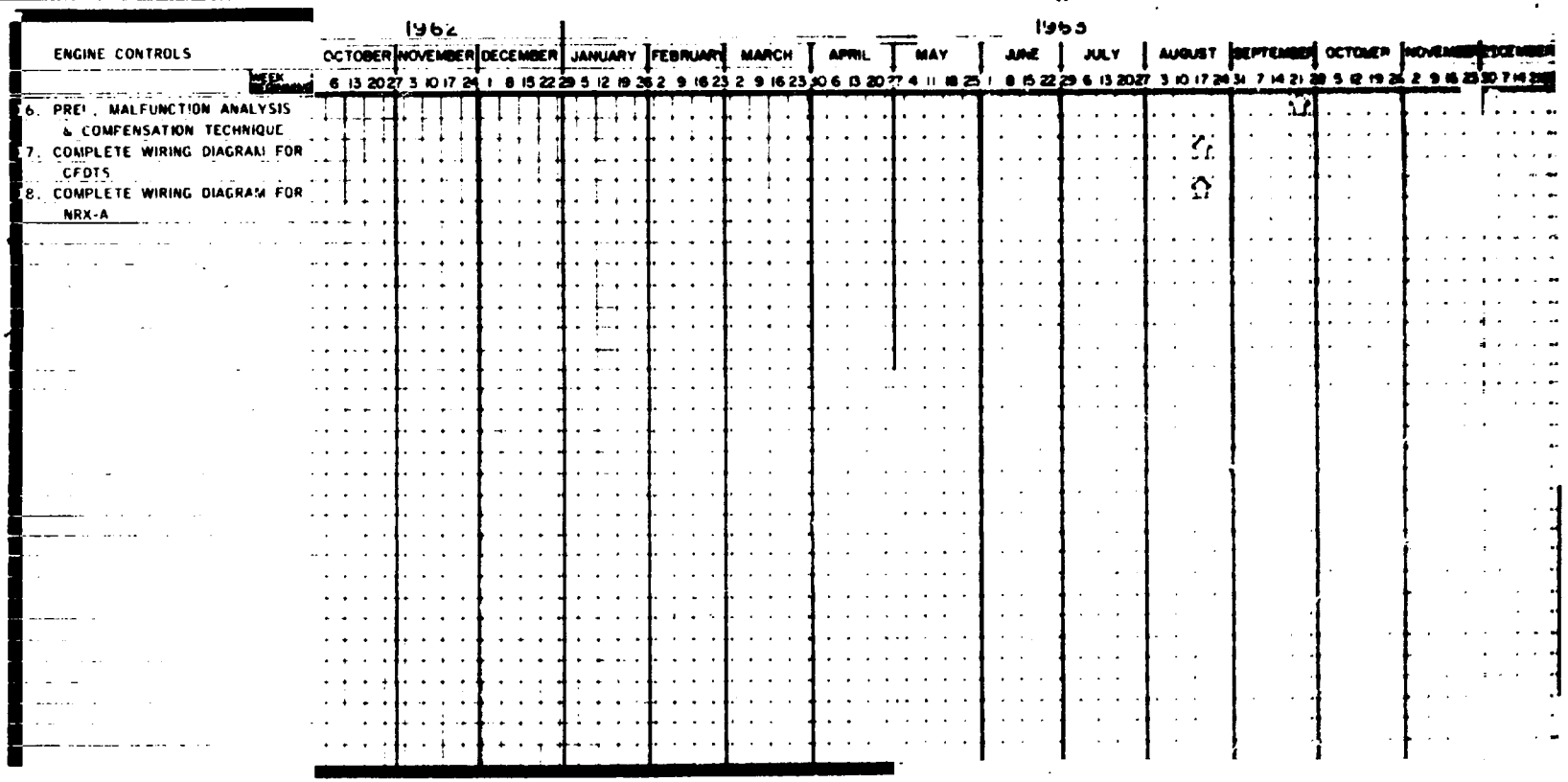
DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 18 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. COMPLETE REQUIREMENTS FOR BLOCK I TPCV ACTUATOR
2. COMPLETE DESIGN OF EXP. TPCV ACTUATOR
3. COMPLETE PRELIMINARY REQUIREMENTS FOR SYSTEM AMP.
4. COMPLETE BB AMPLIFIER DESIGN
5. COMPLETE EXP. AMPLIFIER DESIGN
6. COMPLETE REQUIREMENTS FOR ENGINE HARNESSES
7. COMPLETE PRELIMINARY REQUIREMENTS FOR PRESSURE & TEMP. SENSORS
8. COMPLETE PRELIM. PROGRAMMER FUNCTIONAL SCHEMATIC
9. COMPLETE DESIGN OF PROGRAMMER RAD. TEST MODULES
10. ESTABLISH DESIGN REQUIREMENTS FOR ETS-1 REMOTE ENGINE CONTROL SIMULATION
11. COMPLETE DESIGN OF ETS-1 REMOTE ENGINE CONTROL SIMULATOR
12. COMPLETE DESIGN REQUIREMENTS FOR ETS-1 REMOTE ENGINE CONTROL SYSTEM
13. COMPLETE VENDOR CAPABILITY STUDY FOR ENGINE HARNESS COMPONENTS
14. LET G.E. CONTRACT
15. PREL. PROGRAMMER DIAGRAM

⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 33 of 63

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.5 (CONT.)


1962
1963
ENGINE CONTROLS
WEEK BEGINNING
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
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AUGUST
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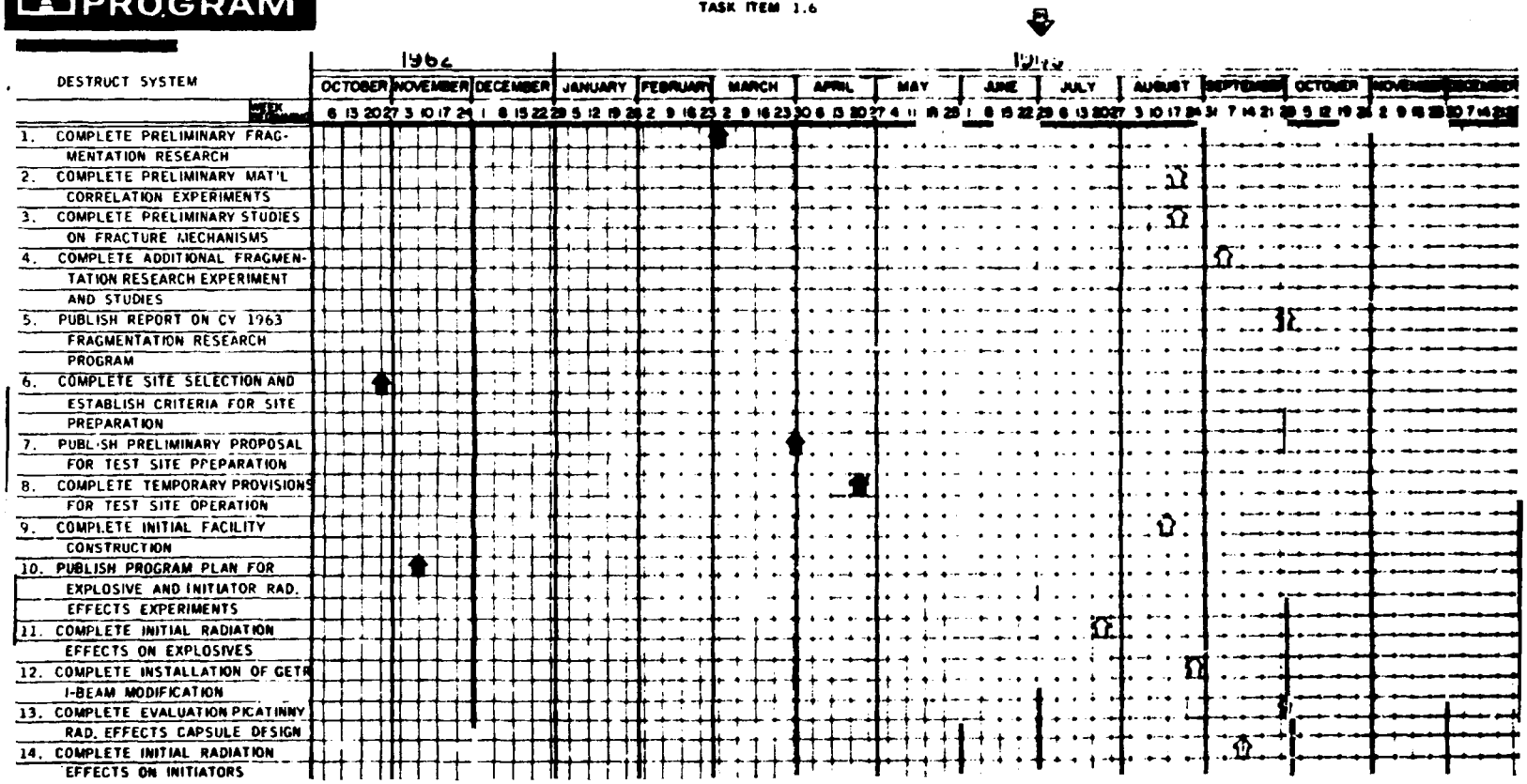
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 25 30 7 14 28
6. PREL. MALFUNCTION ANALYSIS & COMPENSATION TECHNIQUE
7. COMPLETE WIRING DIAGRAM FOR CFDTS
8. COMPLETE WIRING DIAGRAM FOR NRX-A

◇ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 34 of 63

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.6



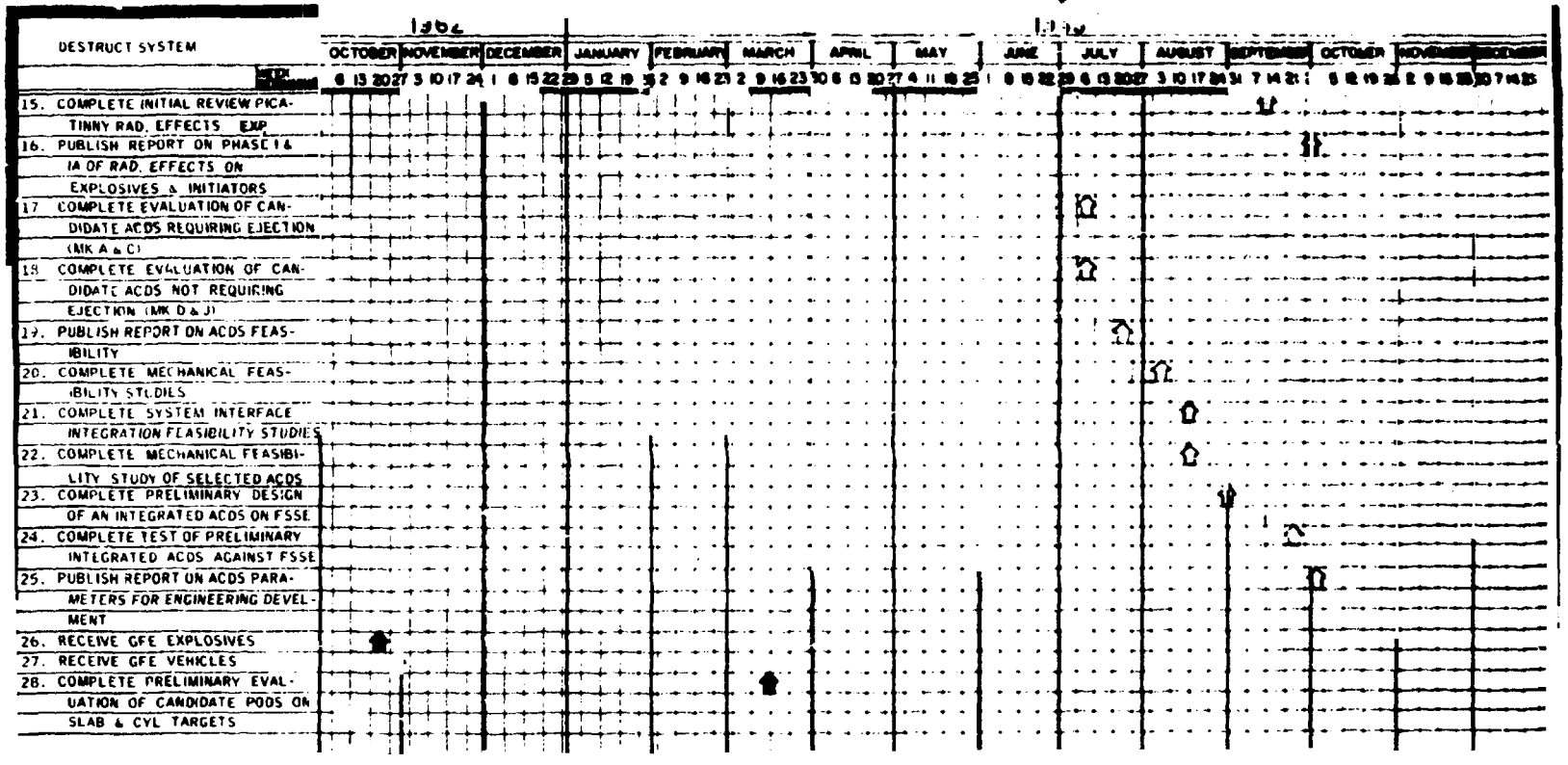
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 35 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.6


1962
1963
DESTRUCT SYSTEM
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
15. COMPLETE INITIAL REVIEW PICATINNY RAD. EFFECTS EXP.
16. PUBLISH REPORT ON PHASE I & IA OF RAD. EFFECTS ON EXPLOSIVES & INITIATORS
17. COMPLETE EVALUATION OF CANDIDATE ACDS REQUIRING EJECTION (MK A & C)
18. COMPLETE EVALUATION OF CANDIDATE ACDS NOT REQUIRING EJECTION (MK D & J)
19. PUBLISH REPORT ON ACDS FEASIBILITY
20. COMPLETE MECHANICAL FEASIBILITY STUDIES
21. COMPLETE SYSTEM INTERFACE INTEGRATION FEASIBILITY STUDIES
22. COMPLETE MECHANICAL FEASIBILITY STUDY OF SELECTED ACDS
23. COMPLETE PRELIMINARY DESIGN OF AN INTEGRATED ACDS ON FSSE
24. COMPLETE TEST OF PRELIMINARY INTEGRATED ACDS AGAINST FSSE
25. PUBLISH REPORT ON ACDS PARAMETERS FOR ENGINEERING DEVELOPMENT
26. RECEIVE GFE EXPLOSIVES
27. RECEIVE GFE VEHICLES
28. COMPLETE PRELIMINARY EVALUATION OF CANDIDATE PODS ON SLAB & CYL TARGETS

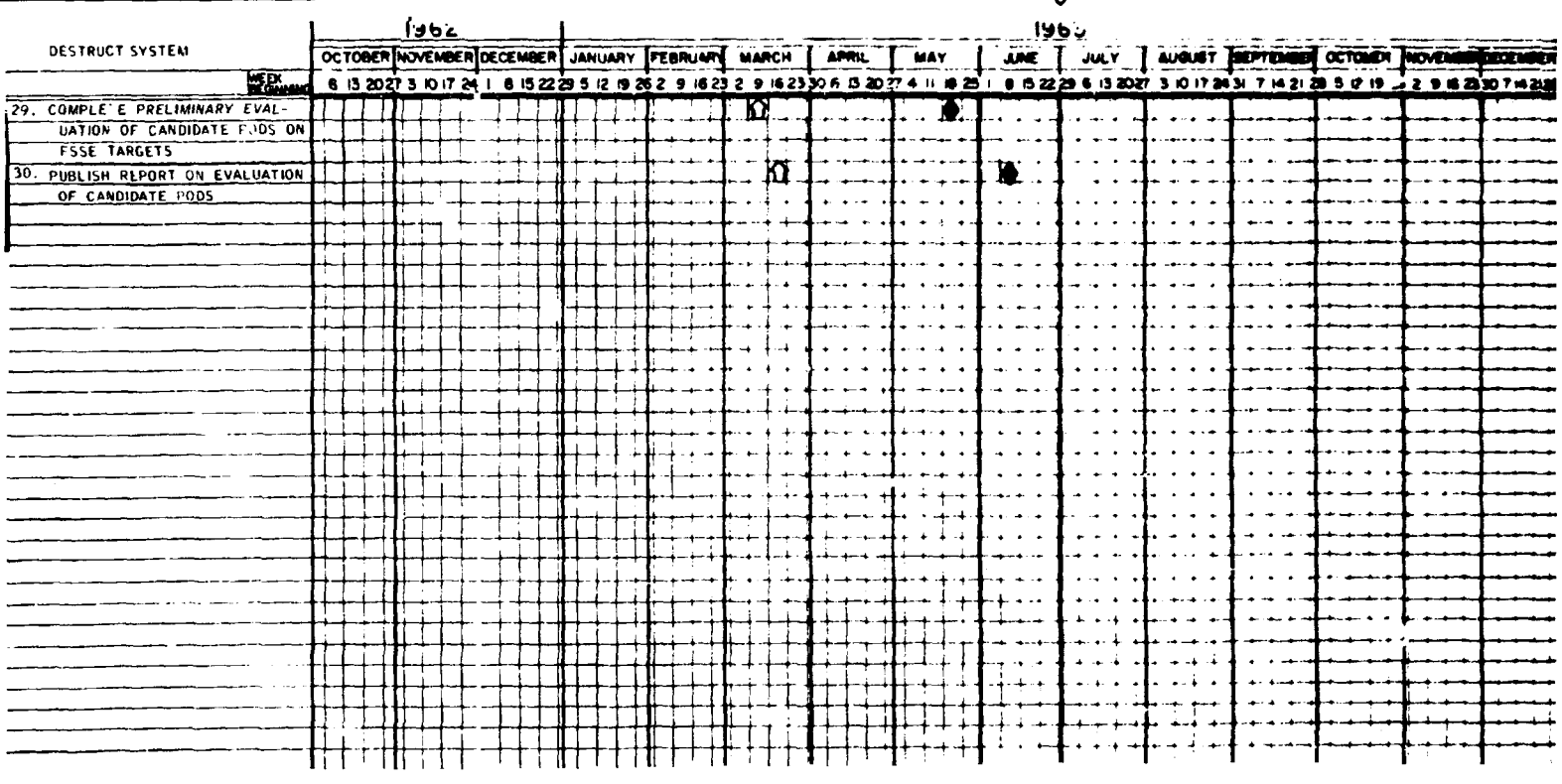
⇧ SCHEDULED MILESTONE
⇩ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 36 of 67

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.6

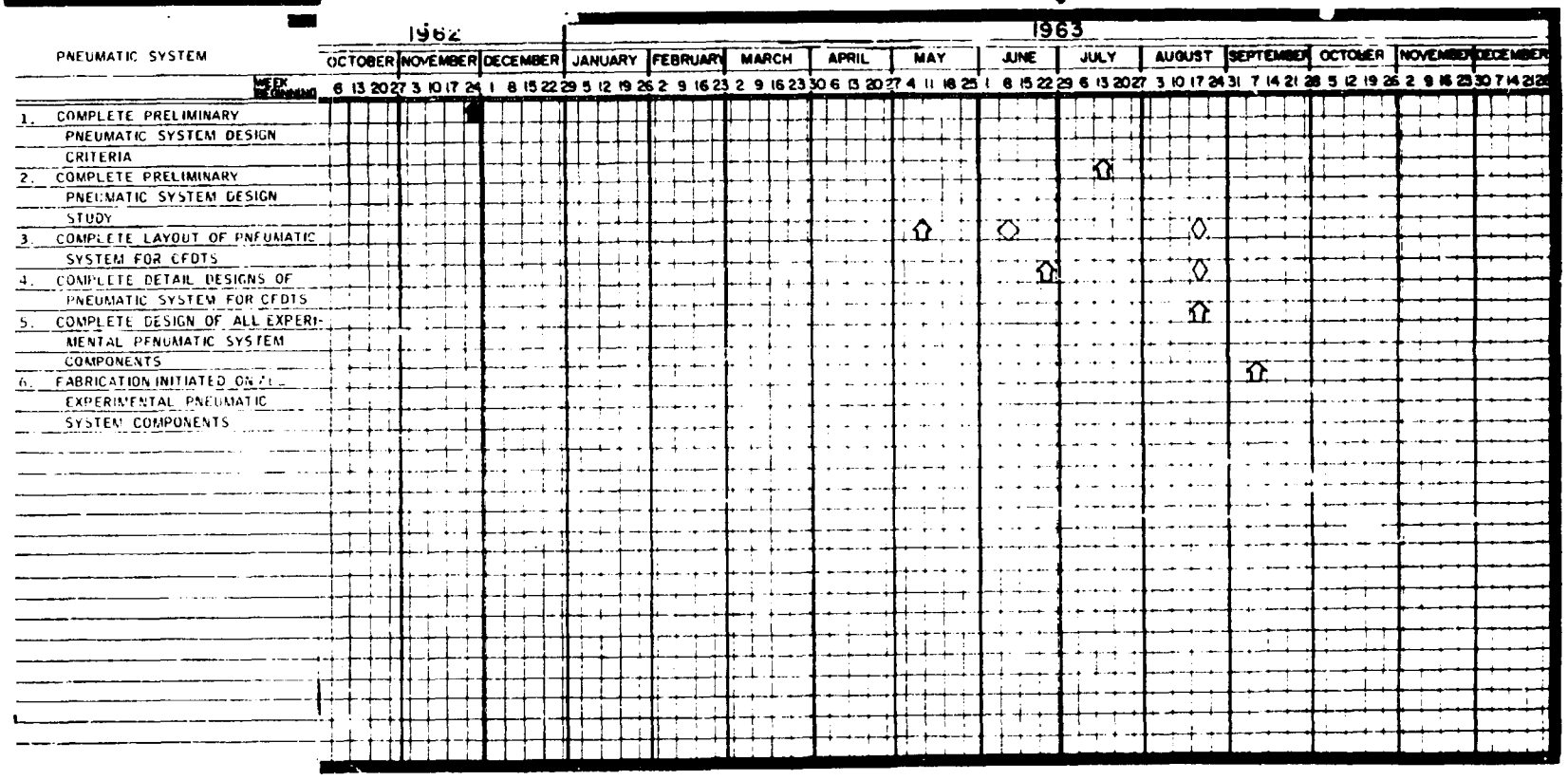

DESTRUCT SYSTEM
1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
WEEK BEGINNING
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 2 9 16 23 30 7 14 21
29. COMPLETE PRELIMINARY EVALUATION OF CANDIDATE PODS ON FSSE TARGETS
30. PUBLISH REPORT ON EVALUATION OF CANDIDATE PODS

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.7

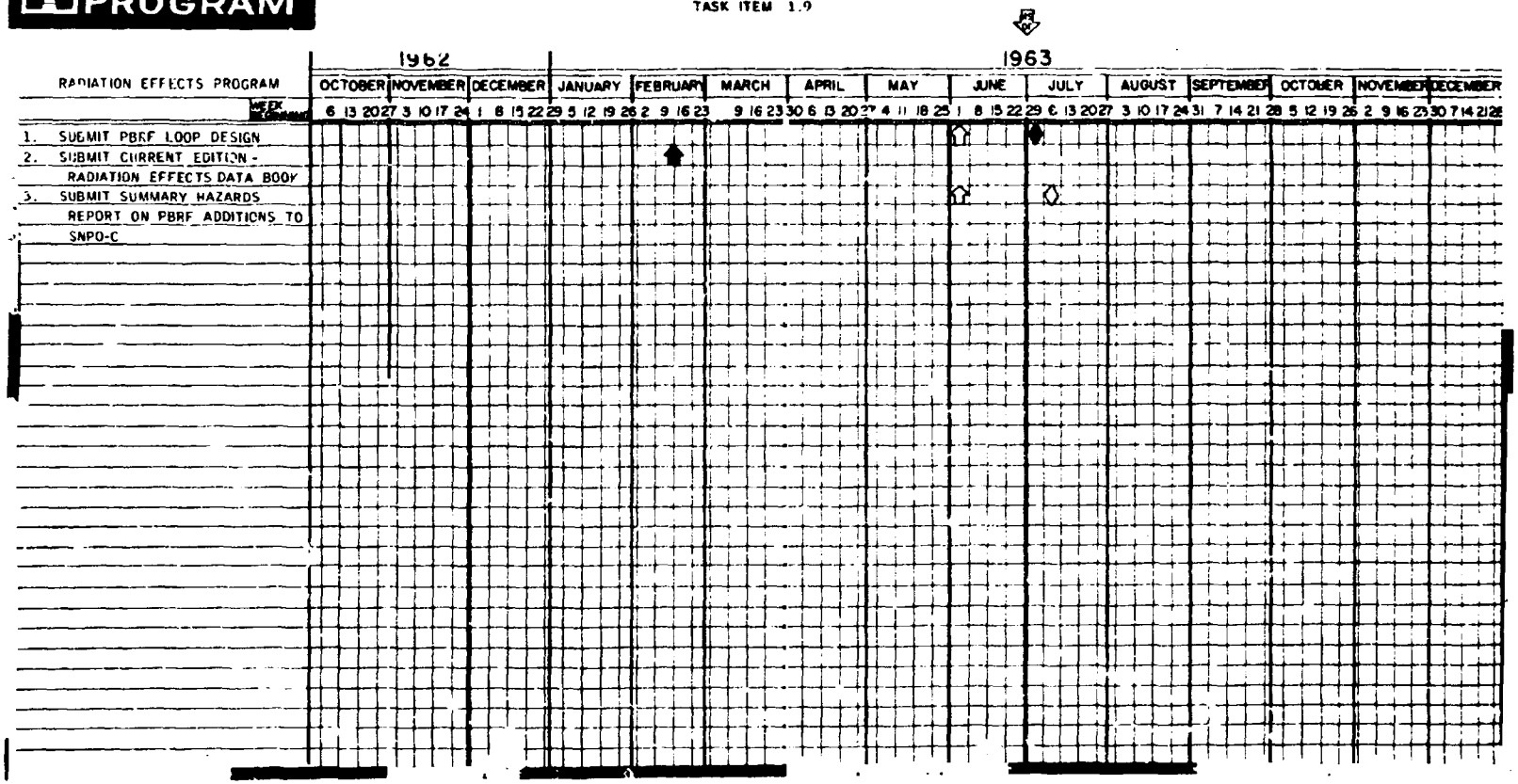


◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 1.9


RADIATION EFFECTS PROGRAM
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK BEGINNING
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. SUBMIT PBRF LOOP DESIGN
2. SUBMIT CURRENT EDITION - RADIATION EFFECTS DATA BOOK
3. SUBMIT SUMMARY HAZARDS REPORT ON PBRF ADDITIONS TO SNPO-C

DATE:

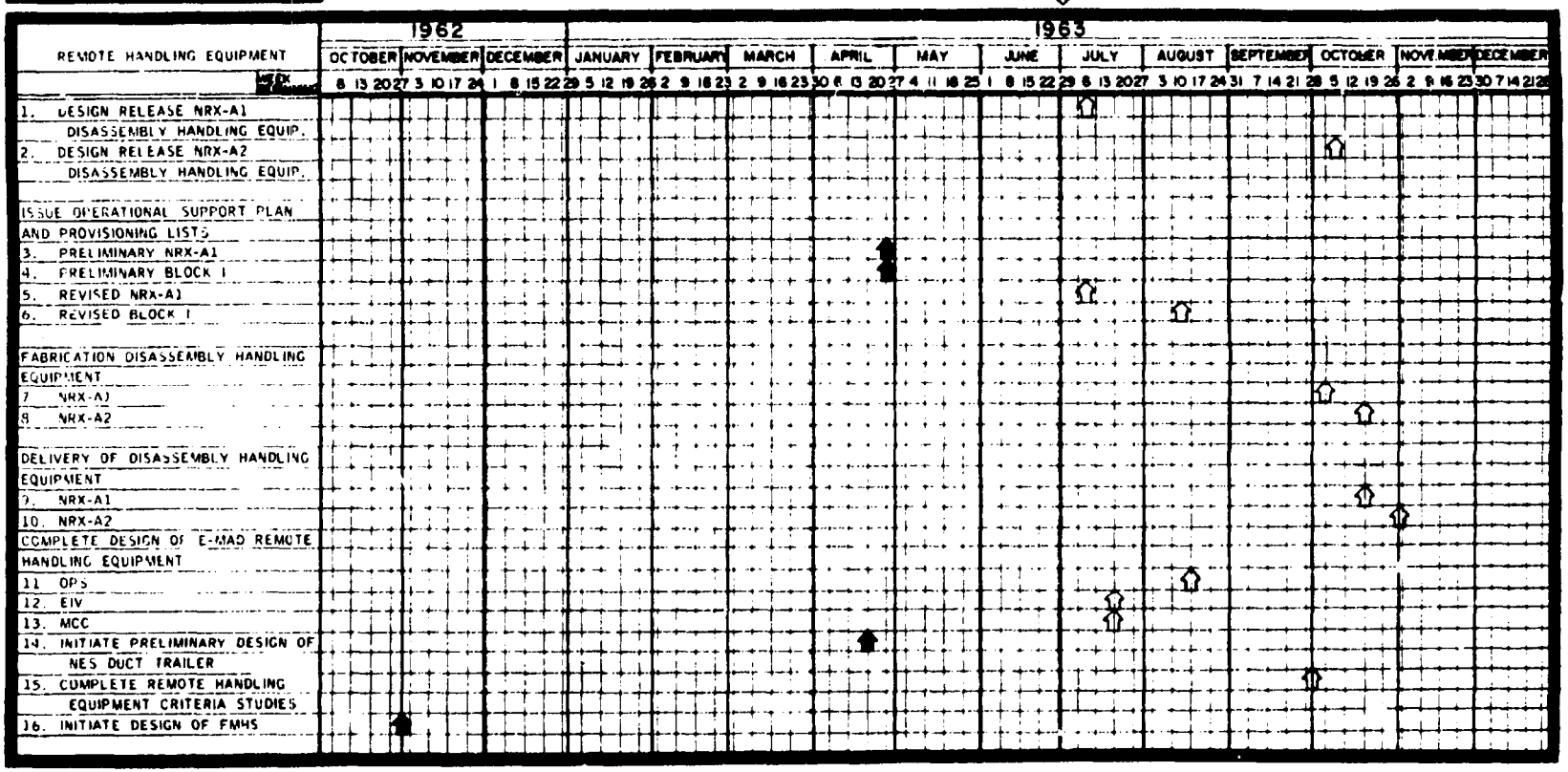
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 39 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.1


1962
1963
REMOTE HANDLING EQUIPMENT
WEEK ENDING
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
8 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. DESIGN RELEASE NRX-A1
DISASSEMBLY HANDLING EQUIP.
2. DESIGN RELEASE NRX-A2
DISASSEMBLY HANDLING EQUIP.
ISSUE OPERATIONAL SUPPORT PLAN AND PROVISIONING LISTS
3. PRELIMINARY NRX-A1
4. PRELIMINARY BLOCK I
5. REVISED NRX-A1
6. REVISED BLOCK I
FABRICATION DISASSEMBLY HANDLING EQUIPMENT
7. NRX-A1
8. NRX-A2
DELIVERY OF DISASSEMBLY HANDLING EQUIPMENT
9. NRX-A1
10. NRX-A2
COMPLETE DESIGN OF E-MAD REMOTE HANDLING EQUIPMENT
11. OPS
12. EIV
13. MCC
14. INITIATE PRELIMINARY DESIGN OF NES DUCT TRAILER
15. COMPLETE REMOTE HANDLING EQUIPMENT CRITERIA STUDIES
16. INITIATE DESIGN OF FMHS

DATE:

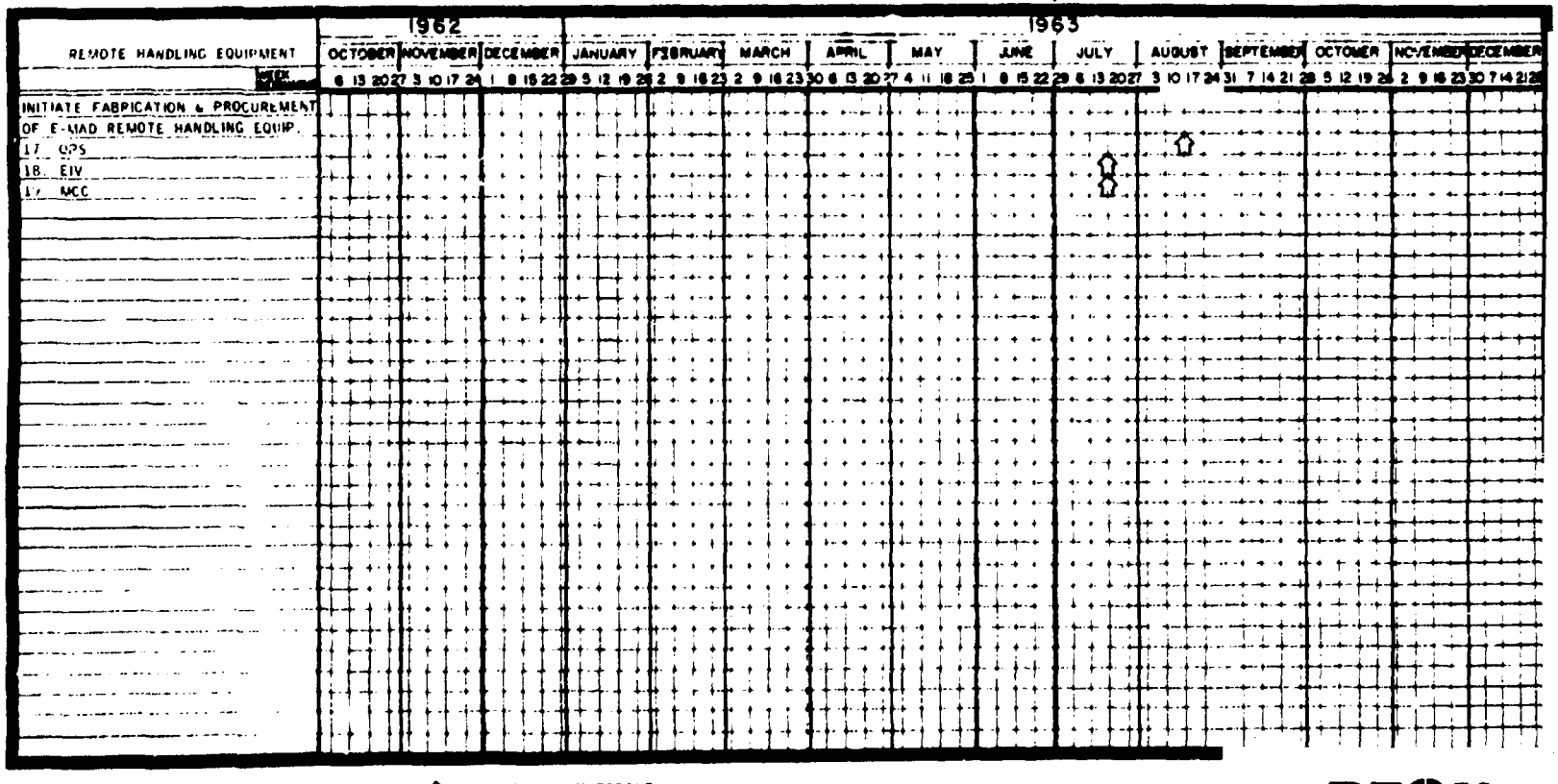
⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 40 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.1



DATE:

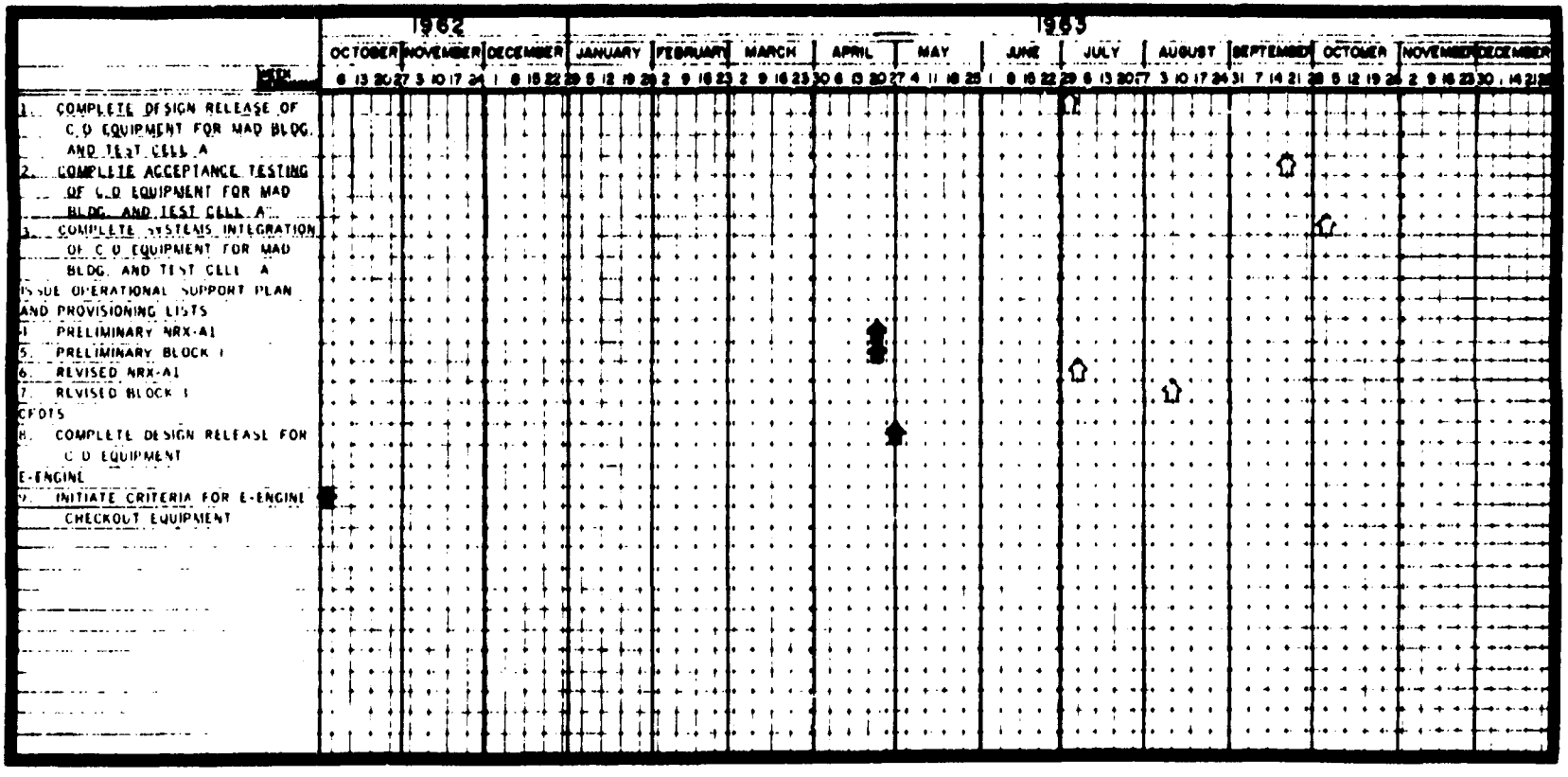
⇧ SCHEDULED MILESTONE
⇧ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 41 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.2



DATE:

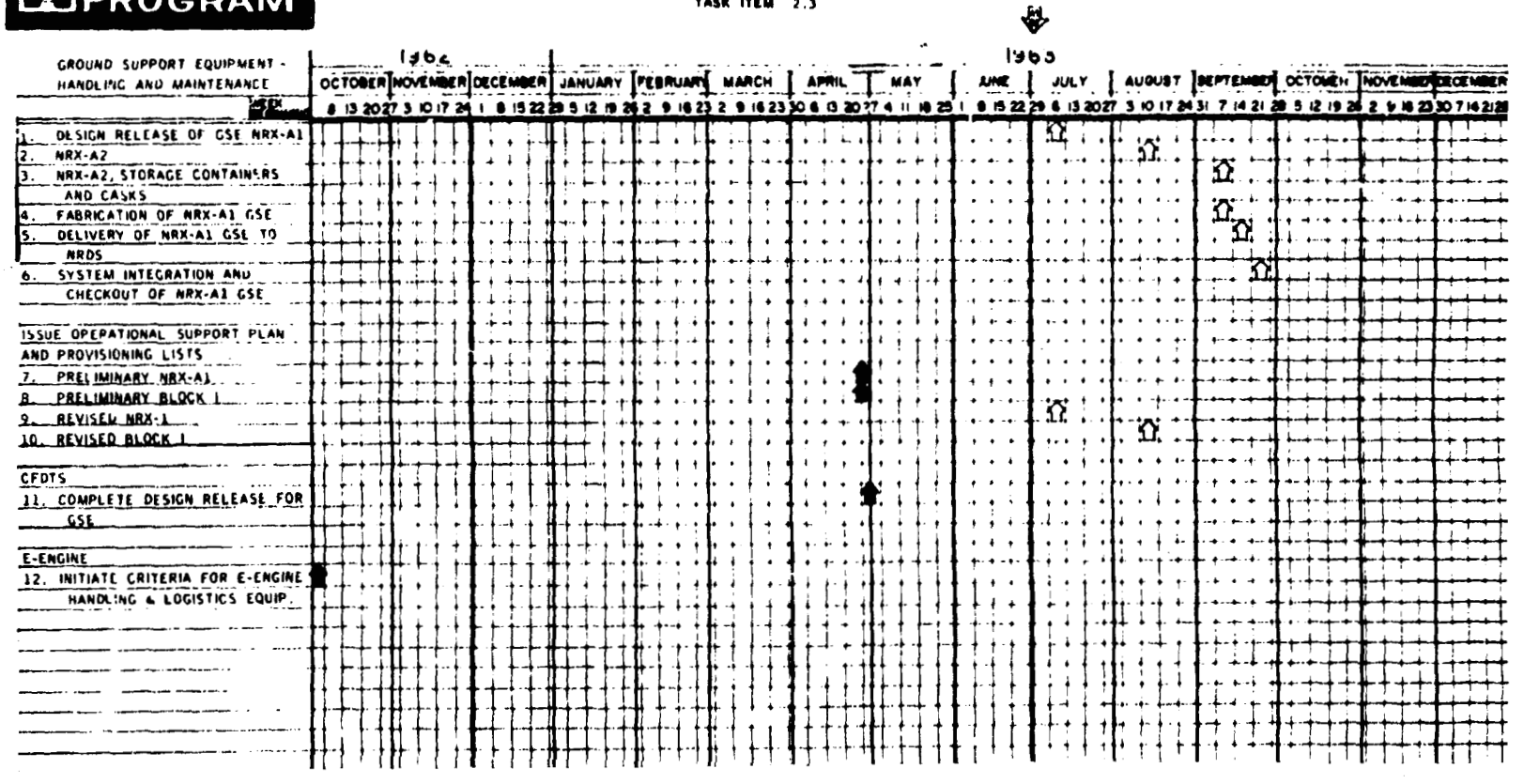
⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 42 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.3


GROUND SUPPORT EQUIPMENT - HANDLING AND MAINTENANCE
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
1. DESIGN RELEASE OF GSE NRX-A1
2. NRX-A2
3. NRX-A2, STORAGE CONTAINERS AND CASKS
4. FABRICATION OF NRX-A1 GSE
5. DELIVERY OF NRX-A1 GSE TO NRDS
6. SYSTEM INTEGRATION AND CHECKOUT OF NRX-A2 GSE
ISSUE OPERATIONAL SUPPORT PLAN AND PROVISIONING LISTS
7. PRELIMINARY NRX-A1
8. PRELIMINARY BLOCK I
9. REVISED NRX-1
10. REVISED BLOCK I
GFDTS
11. COMPLETE DESIGN RELEASE FOR GSE
E-ENGINE
12. INITIATE CRITERIA FOR E-ENGINE HANDLING & LOGISTICS EQUIP.

DATE:

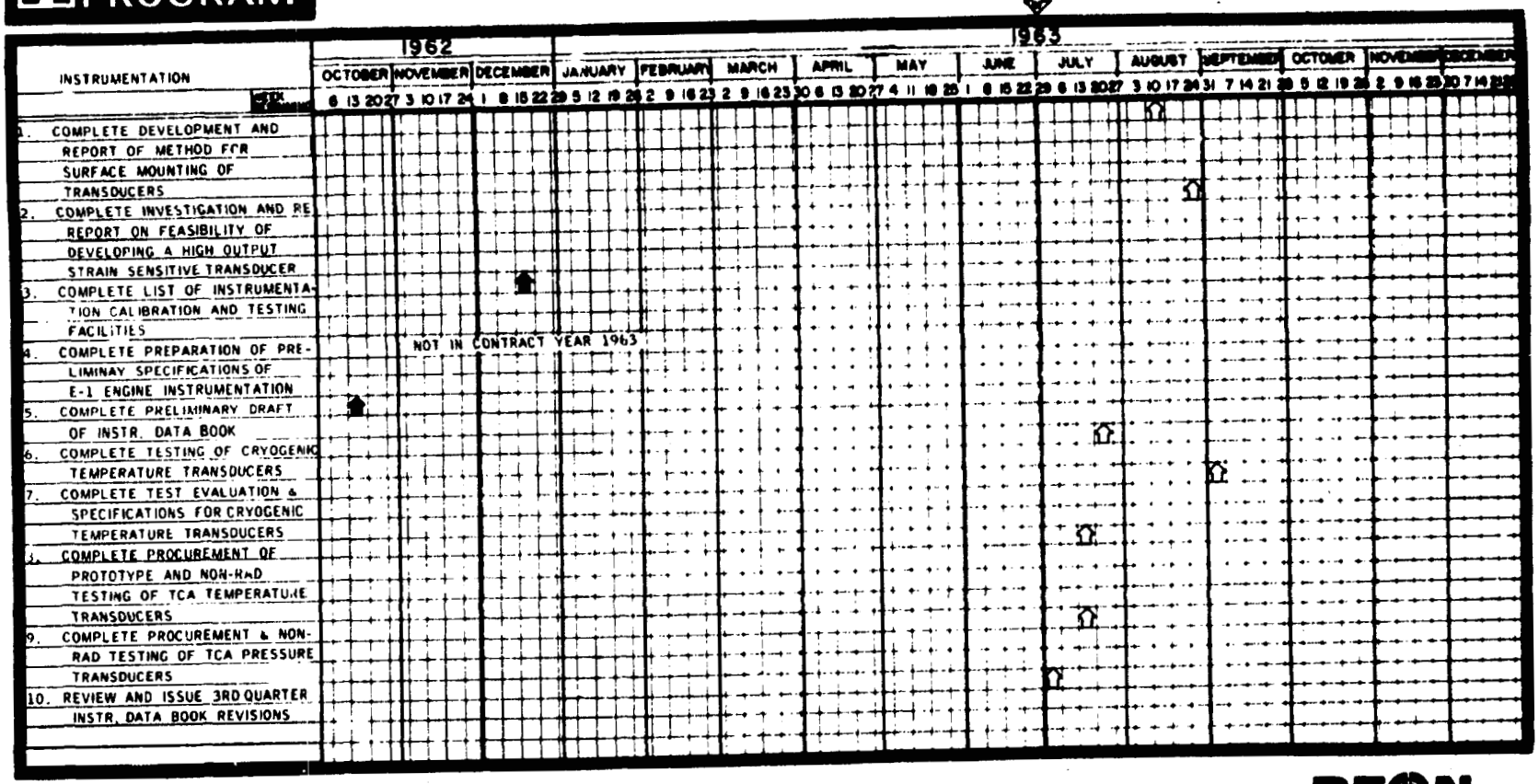
⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 43 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.4


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
INSTRUMENTATION
1. COMPLETE DEVELOPMENT AND REPORT OF METHOD FOR SURFACE MOUNTING OF TRANSDUCERS
2. COMPLETE INVESTIGATION AND RE REPORT ON FEASIBILITY OF DEVELOPING A HIGH OUTPUT STRAIN SENSITIVE TRANSDUCER
3. COMPLETE LIST OF INSTRUMENTATION CALIBRATION AND TESTING FACILITIES
4. COMPLETE PREPARATION OF PRELIMINAY SPECIFICATIONS OF E-1 ENGINE INSTRUMENTATION
5. COMPLETE PRELIMINARY DRAFT OF INSTR. DATA BOOK
6. COMPLETE TESTING OF CRYOGENIC TEMPERATURE TRANSDUCERS
7. COMPLETE TEST EVALUATION & SPECIFICATIONS FOR CRYOGENIC TEMPERATURE TRANSDUCERS
8. COMPLETE PROCUREMENT OF PROTOTYPE AND NON-RAD TESTING OF TCA TEMPERATURE TRANSDUCERS
9. COMPLETE PROCUREMENT & NON-RAD TESTING OF TCA PRESSURE TRANSDUCERS
10. REVIEW AND ISSUE 3RD QUARTER INSTR. DATA BOOK REVISIONS
NOT IN CONTRACT YEAR 1963

DATE:

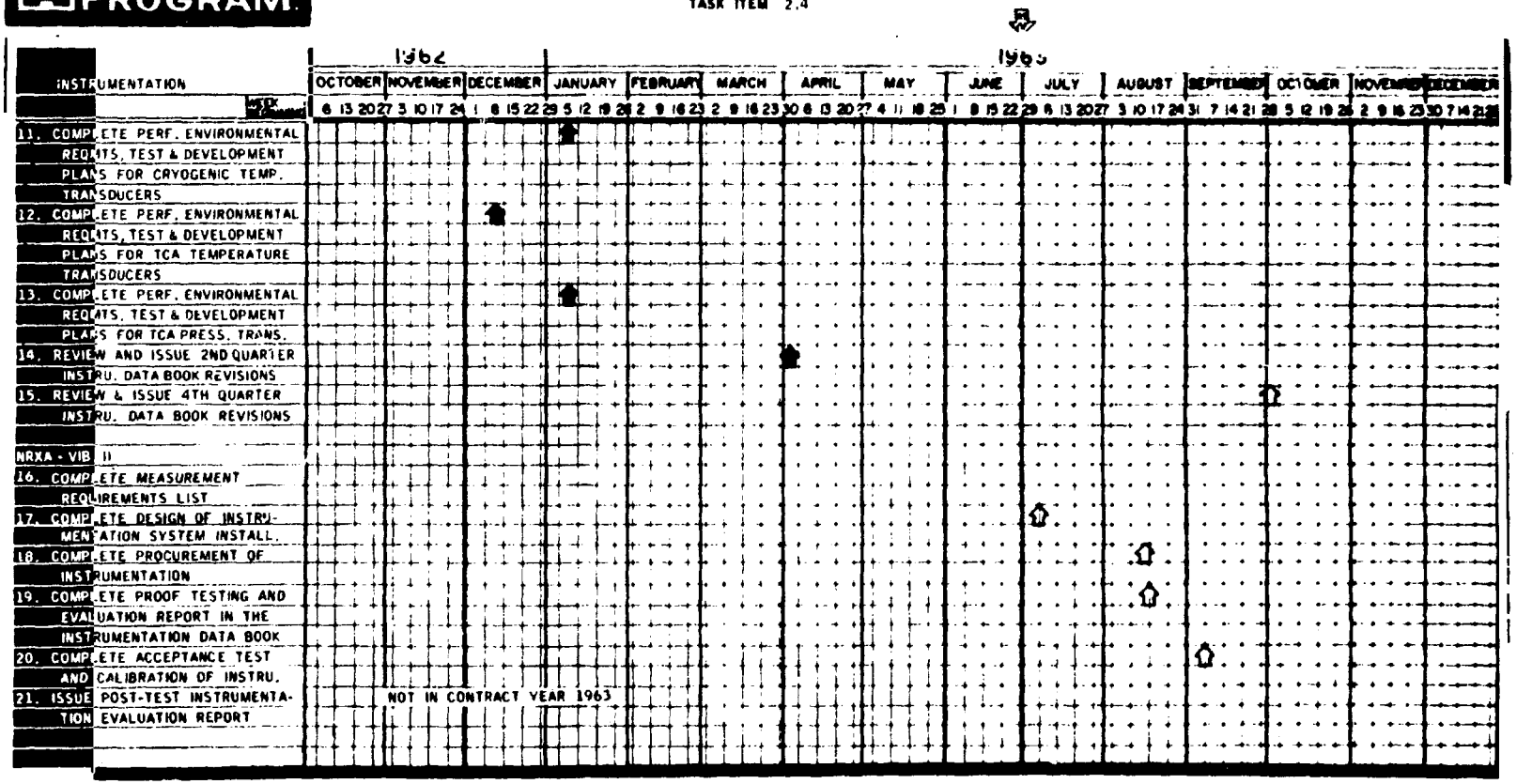
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 44 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.4


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
INSTRUMENTATION
11. COMPLETE PERF. ENVIRONMENTAL REQTS. TEST & DEVELOPMENT PLANS FOR CRYOGENIC TEMP. TRANSDUCERS
12. COMPLETE PERF. ENVIRONMENTAL REQTS. TEST & DEVELOPMENT PLANS FOR TCA TEMPERATURE TRANSDUCERS
13. COMPLETE PERF. ENVIRONMENTAL REQTS. TEST & DEVELOPMENT PLANS FOR TCA PRESS. TRANS.
14. REVIEW AND ISSUE 2ND QUARTER INSTRU. DATA BOOK REVISIONS
15. REVIEW & ISSUE 4TH QUARTER INSTRU. DATA BOOK REVISIONS
NRXA - VIB II
16. COMPLETE MEASUREMENT REQUIREMENTS LIST
17. COMPLETE DESIGN OF INSTRU-MENTATION SYSTEM INSTALL.
18. COMPLETE PROCUREMENT OF INSTRUMENTATION
19. COMPLETE PROOF TESTING AND EVALUATION REPORT IN THE INSTRUMENTATION DATA BOOK
20. COMPLETE ACCEPTANCE TEST AND CALIBRATION OF INSTRU.
21. ISSUE POST-TEST INSTRUMENTA-TION EVALUATION REPORT
NOT IN CONTRACT YEAR 1963

DATE:

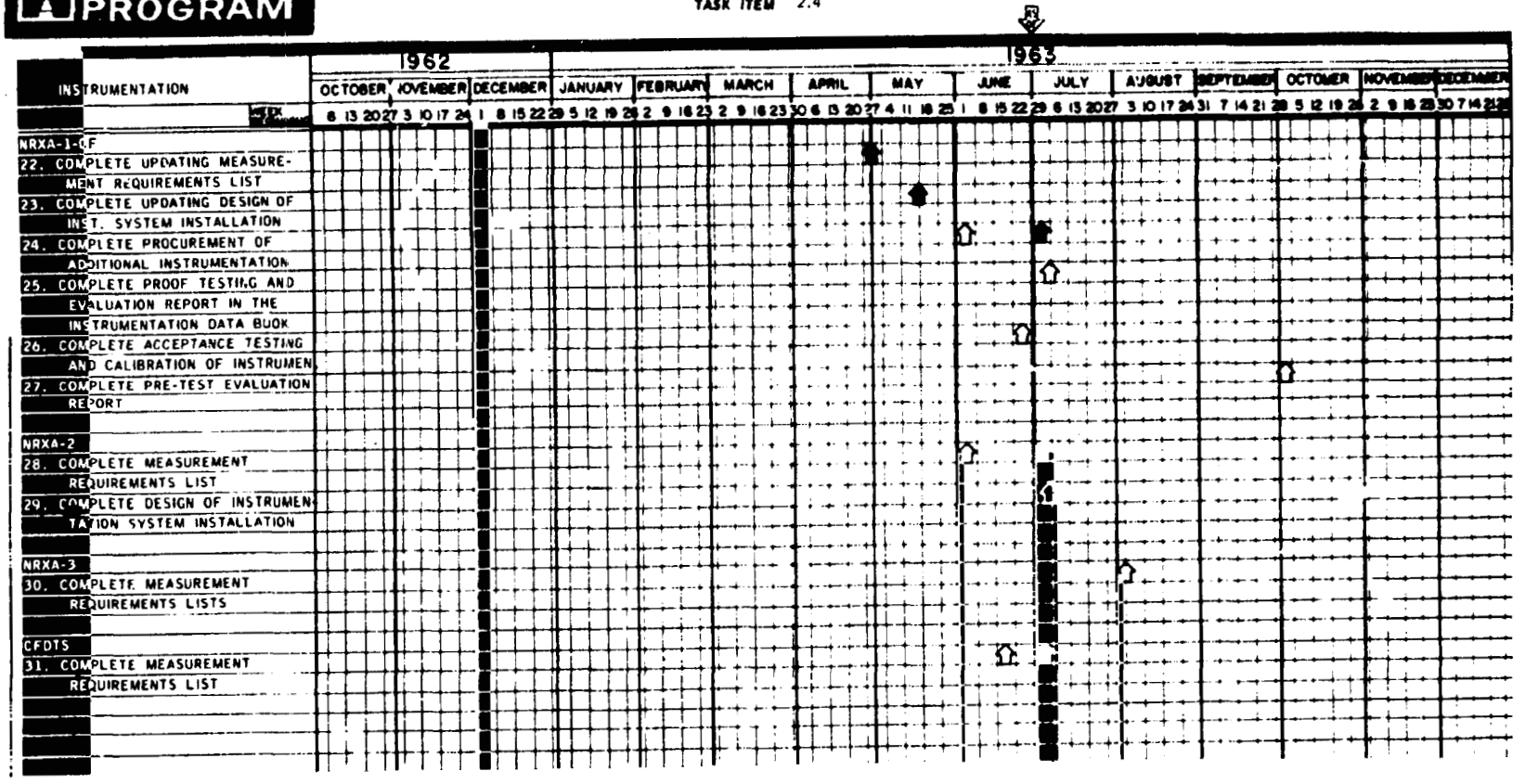
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 45 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.4



DATE:

- ⇧ SCHEDULED MILESTONE
- ◇ RESCHEDULED MILESTONE
- ⬟ MILESTONE ACHIEVEMENT
- ◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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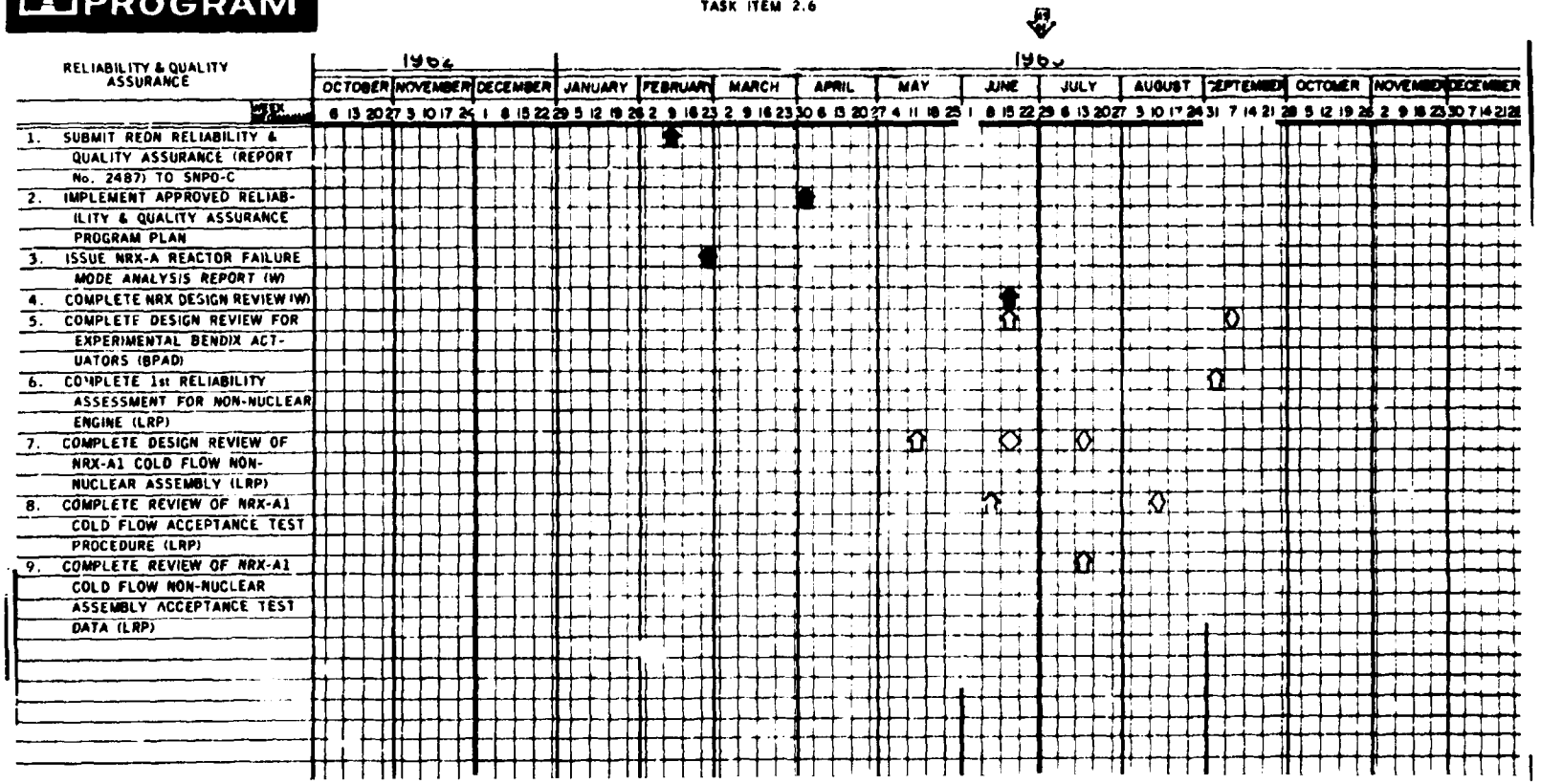
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.6


RELIABILITY & QUALITY ASSURANCE
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. SUBMIT REON RELIABILITY & QUALITY ASSURANCE (REPORT No. 2487) TO SNPO-C
2. IMPLEMENT APPROVED RELIABILITY & QUALITY ASSURANCE PROGRAM PLAN
3. ISSUE NRX-A REACTOR FAILURE MODE ANALYSIS REPORT (W)
4. COMPLETE NRX DESIGN REVIEW (W)
5. COMPLETE DESIGN REVIEW FOR EXPERIMENTAL BENDIX ACTUATORS (BPAD)
6. COMPLETE 1st RELIABILITY ASSESSMENT FOR NON-NUCLEAR ENGINE (LRP)
7. COMPLETE DESIGN REVIEW OF NRX-A1 COLD FLOW NON-NUCLEAR ASSEMBLY (LRP)
8. COMPLETE REVIEW OF NRX-A1 COLD FLOW ACCEPTANCE TEST PROCEDURE (LRP)
9. COMPLETE REVIEW OF NRX-A1 COLD FLOW NON-NUCLEAR ASSEMBLY ACCEPTANCE TEST DATA (LRP)

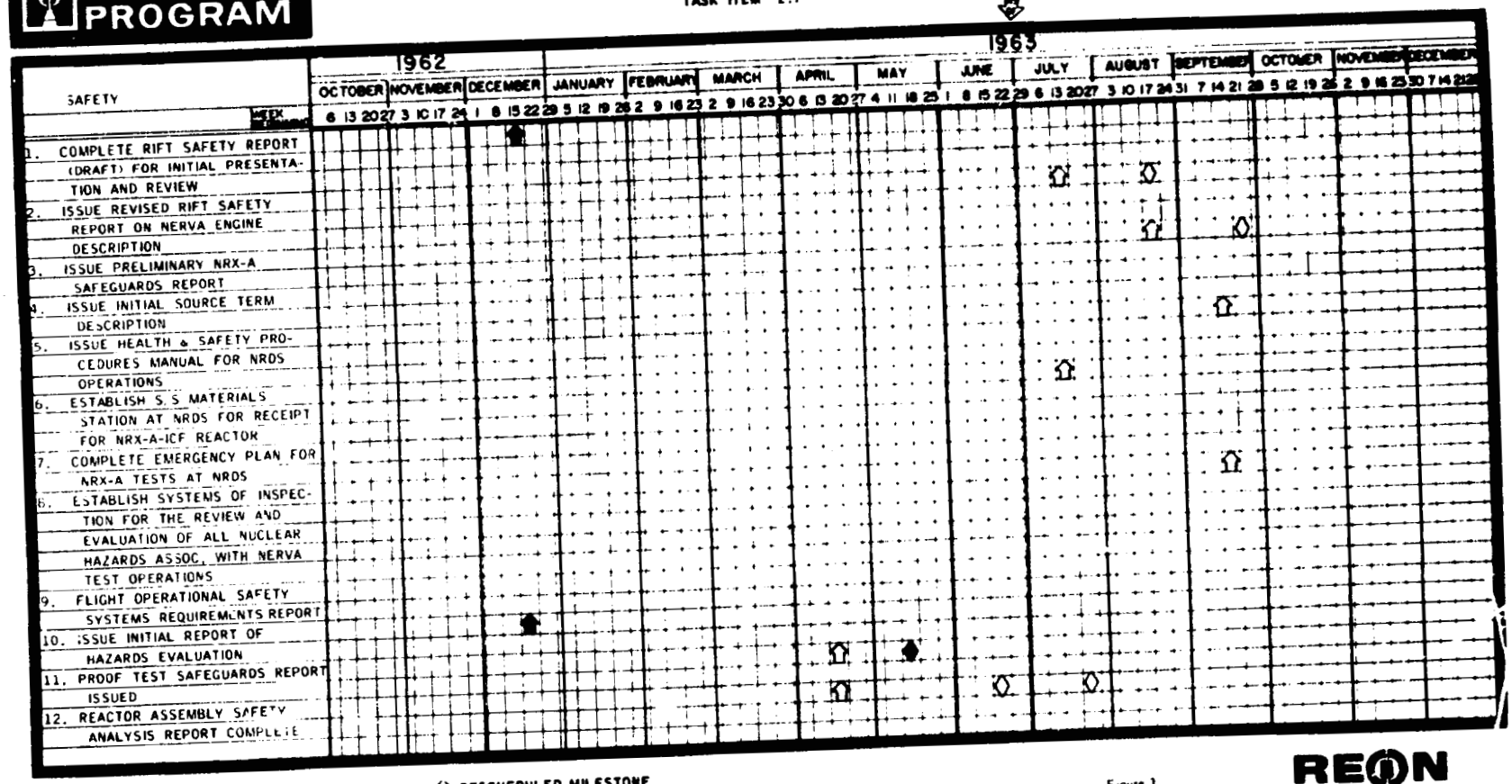
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 47 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.7


SAFETY
1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1. COMPLETE RIFT SAFETY REPORT (DRAFT) FOR INITIAL PRESENTATION AND REVIEW
2. ISSUE REVISED RIFT SAFETY REPORT ON NERVA ENGINE DESCRIPTION
3. ISSUE PRELIMINARY NRX-A SAFEGUARDS REPORT
4. ISSUE INITIAL SOURCE TERM DESCRIPTION
5. ISSUE HEALTH & SAFETY PROCEDURES MANUAL FOR NRDS OPERATIONS
6. ESTABLISH S.S MATERIALS STATION AT NRDS FOR RECEIPT FOR NRX-A-ICF REACTOR
7. COMPLETE EMERGENCY PLAN FOR NRX-A TESTS AT NRDS
8. ESTABLISH SYSTEMS OF INSPECTION FOR THE REVIEW AND EVALUATION OF ALL NUCLEAR HAZARDS ASSOC. WITH NERVA TEST OPERATIONS
9. FLIGHT OPERATIONAL SAFETY SYSTEMS REQUIREMENTS REPORT
10. ISSUE INITIAL REPORT OF HAZARDS EVALUATION
11. PROOF TEST SAFEGUARDS REPORT ISSUED
12. REACTOR ASSEMBLY SAFETY ANALYSIS REPORT COMPLETE

DATE:

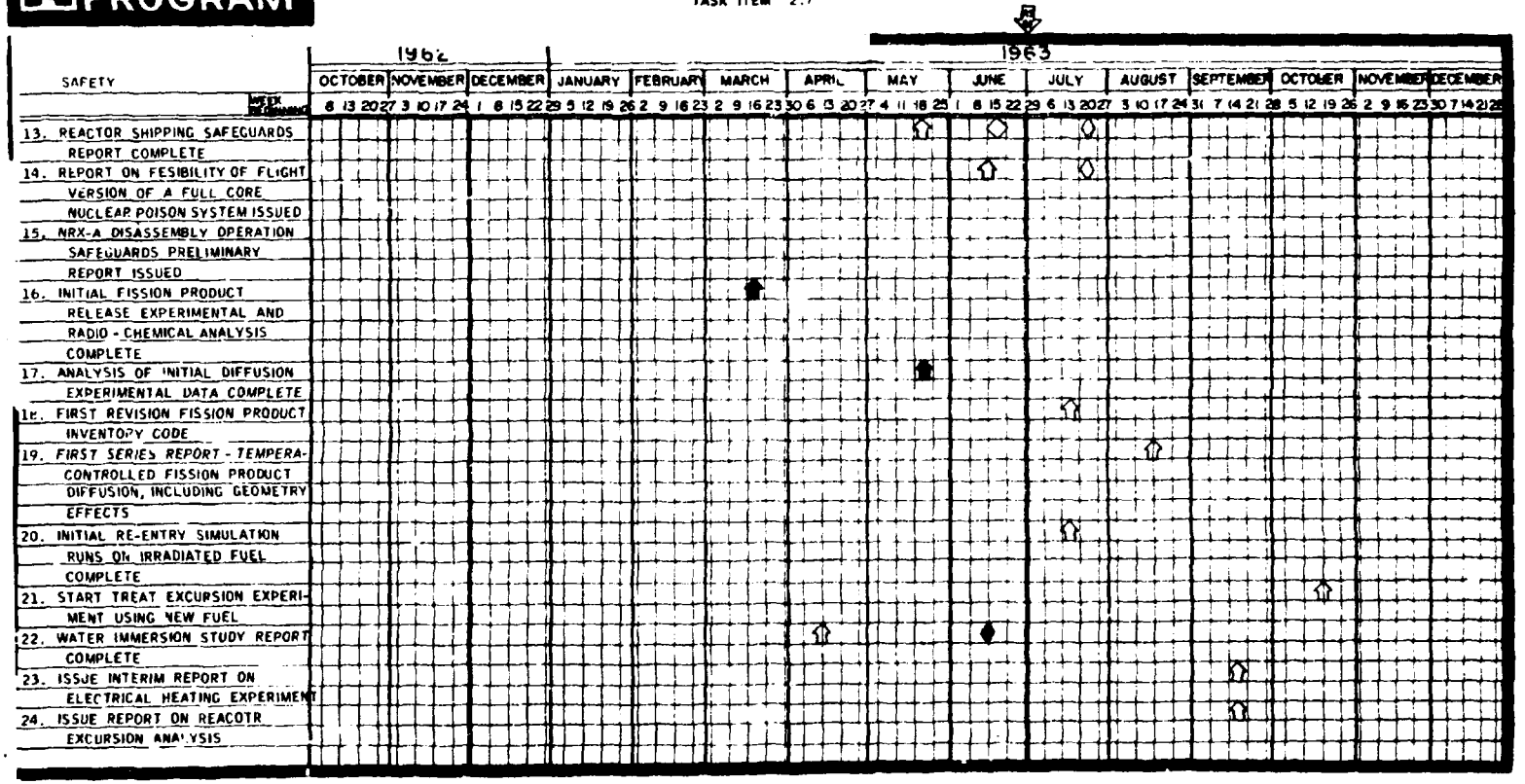
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 48 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.7


1962
1963
SAFETY
WEEK BEGINNING
OCTOBER 6 13 20 27
NOVEMBER 3 10 17 24
DECEMBER 1 8 15 22 29
JANUARY 5 12 19 26
FEBRUARY 2 9 16 23
MARCH 2 9 16 23 30
APRIL 6 13 20 27
MAY 4 11 18 25
JUNE 1 8 15 22 29
JULY 6 13 20 27
AUGUST 3 10 17 24 31
SEPTEMBER 7 14 21 28
OCTOBER 5 12 19 26
NOVEMBER 2 9 16 23 30
DECEMBER 7 14 21 28
13. REACTOR SHIPPING SAFEGUARDS REPORT COMPLETE
14. REPORT ON FESIBILITY OF FLIGHT VERSION OF A FULL CORE NUCLEAR POISON SYSTEM ISSUED
15. NRX-A DISASSEMBLY OPERATION SAFEGUARDS PRELIMINARY REPORT ISSUED
16. INITIAL FISSION PRODUCT RELEASE EXPERIMENTAL AND RADIO - CHEMICAL ANALYSIS COMPLETE
17. ANALYSIS OF INITIAL DIFFUSION EXPERIMENTAL DATA COMPLETE
18. FIRST REVISION FISSION PRODUCT INVENTORY CODE
19. FIRST SERIES REPORT - TEMPERA- CONTROLLED FISSION PRODUCT DIFFUSION, INCLUDING GEOMETRY EFFECTS
20. INITIAL RE-ENTRY SIMULATION RUNS ON IRRADIATED FUEL COMPLETE
21. START TREAT EXCURSION EXPERI- MENT USING NEW FUEL
22. WATER IMMERSION STUDY REPORT COMPLETE
23. ISSUE INTERIM REPORT ON ELECTRICAL HEATING EXPERIMENT
24. ISSUE REPORT ON REACOTR EXCURSION ANALYSIS

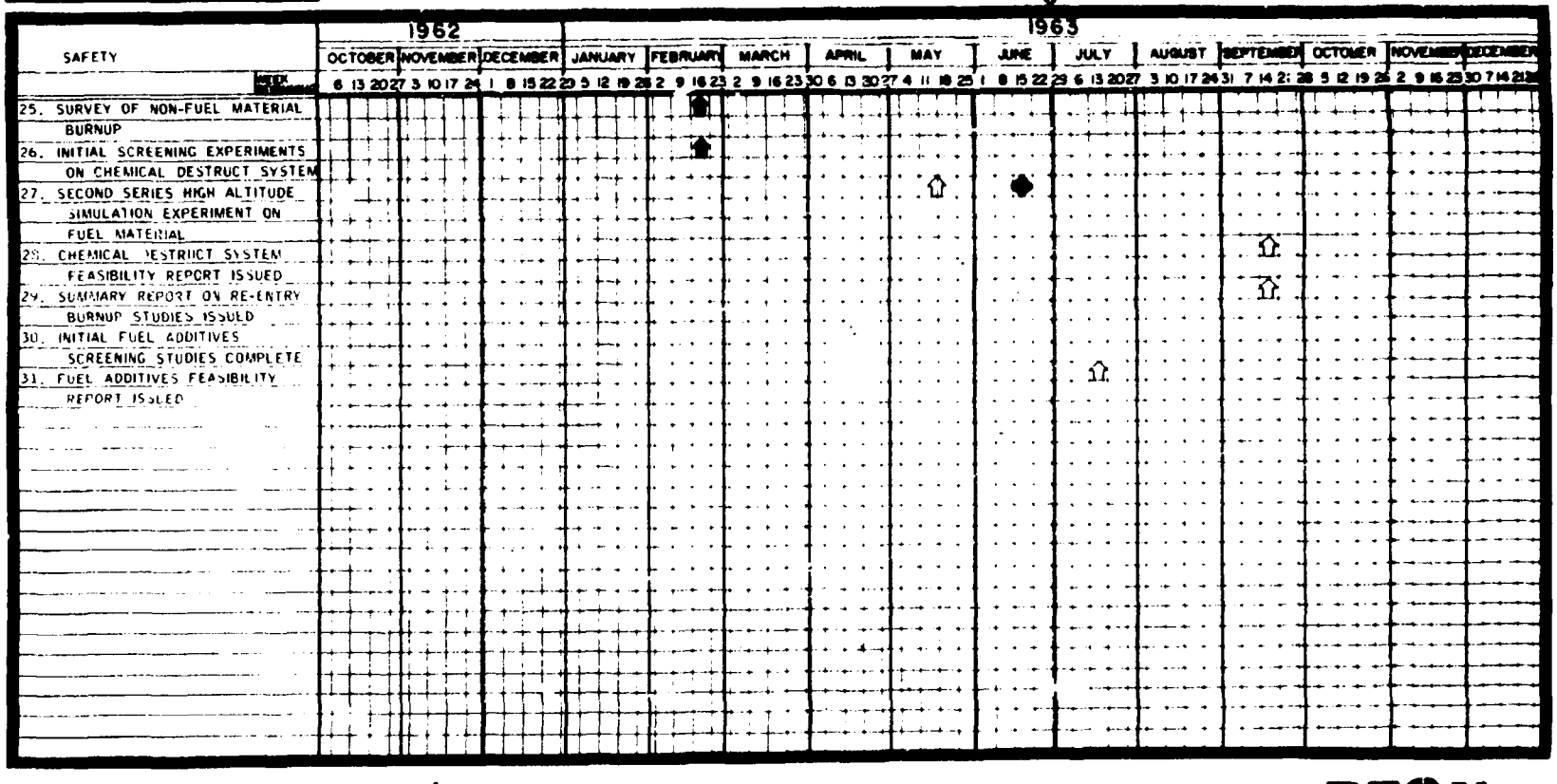
DATE:

⇧ SCHEDULED MILESTONE
⇩ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2 7



DATE:

⇧ SCHEDULED MILESTONE

◇ RESCHEDULED MILESTONE

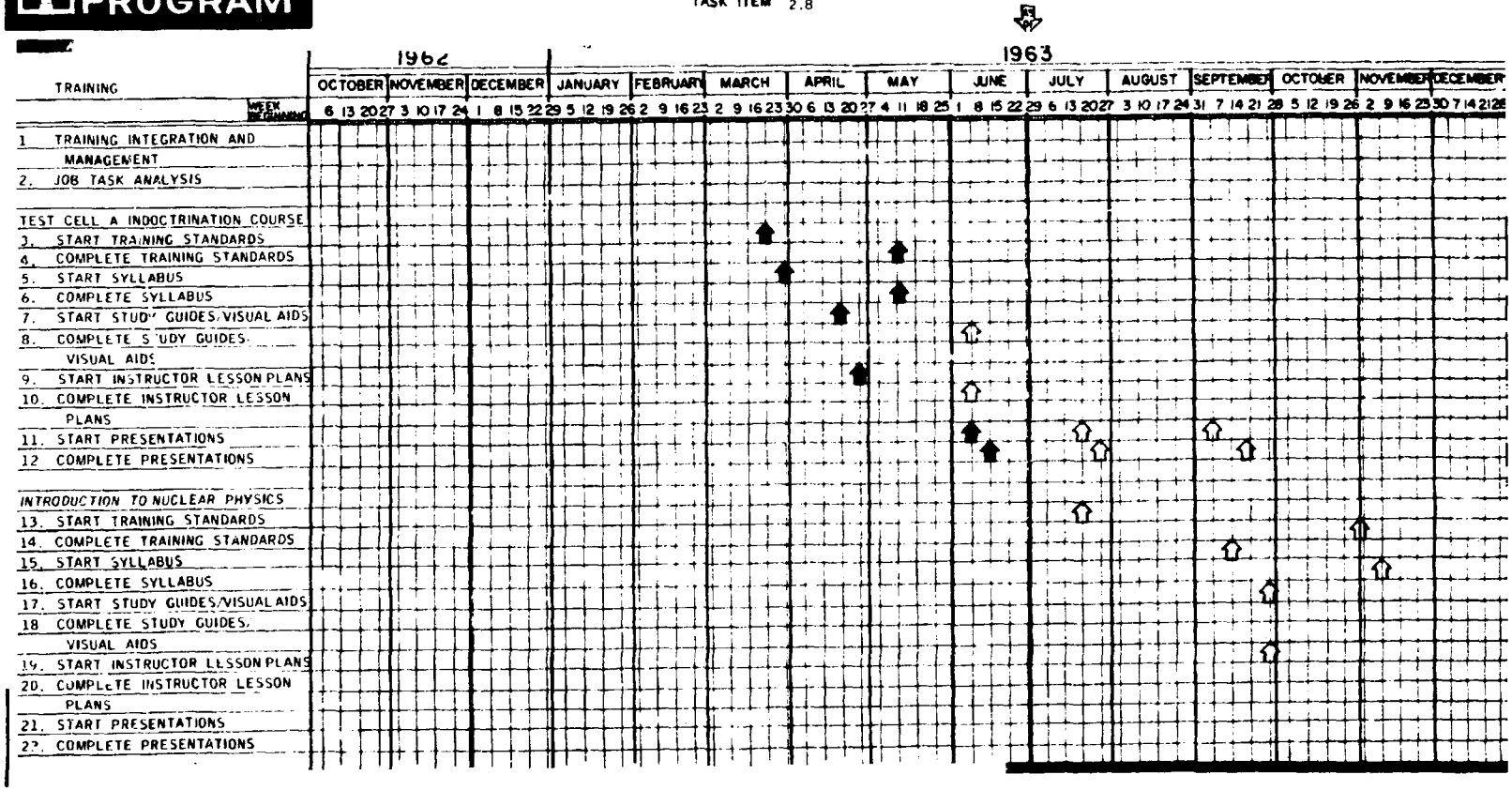
⬟ MILESTONE ACHIEVEMENT

◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.8


1962
1963
TRAINING
WEEK BEGINNING
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1 TRAINING INTEGRATION AND MANAGEMENT
2. JOB TASK ANALYSIS
TEST CELL A INDOCTRINATION COURSE
3. START TRAINING STANDARDS
4. COMPLETE TRAINING STANDARDS
5. START SYLLABUS
6. COMPLETE SYLLABUS
7. START STUDY GUIDES/VISUAL AIDS
8. COMPLETE STUDY GUIDES VISUAL AIDS
9. START INSTRUCTOR LESSON PLANS
10. COMPLETE INSTRUCTOR LESSON PLANS
11. START PRESENTATIONS
12 COMPLETE PRESENTATIONS
INTRODUCTION TO NUCLEAR PHYSICS
13. START TRAINING STANDARDS
14. COMPLETE TRAINING STANDARDS
15. START SYLLABUS
16. COMPLETE SYLLABUS
17. START STUDY GUIDES/VISUAL AIDS
18 COMPLETE STUDY GUIDES VISUAL AIDS
19. START INSTRUCTOR LESSON PLANS
20. COMPLETE INSTRUCTOR LESSON PLANS
21. START PRESENTATIONS
22. COMPLETE PRESENTATIONS

DATE:

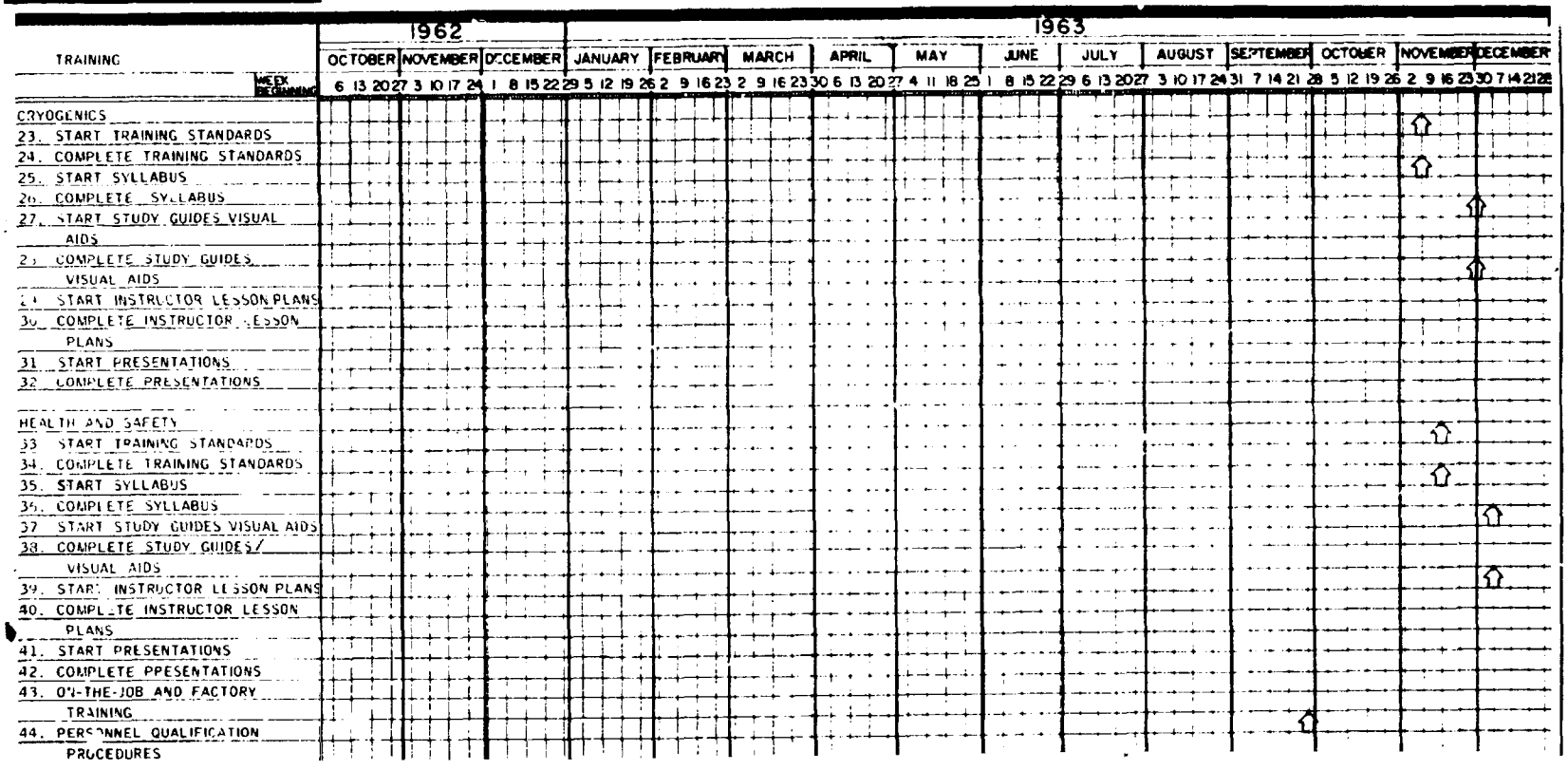
⇧ SCHEDULED MILESTONE
⇩ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 51 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 2.8


1962
1963
TRAINING
WEEK BEGINNING
OCTOBER 6 13 20 27
NOVEMBER 3 10 17 24
DECEMBER 1 8 15 22 29
JANUARY 5 12 19 26
FEBRUARY 2 9 16 23
MARCH 2 9 16 23 30
APRIL 6 13 20 27
MAY 4 11 18 25
JUNE 1 8 15 22 29
JULY 6 13 20 27
AUGUST 3 10 17 24 31
SEPTEMBER 7 14 21 28
OCTOBER 5 12 19 26
NOVEMBER 2 9 16 23 30
DECEMBER 7 14 21 28
CRYOGENICS
23. START TRAINING STANDARDS
24. COMPLETE TRAINING STANDARDS
25. START SYLLABUS
26. COMPLETE SYLLABUS
27. START STUDY GUIDES VISUAL AIDS
28. COMPLETE STUDY GUIDES VISUAL AIDS
29. START INSTRUCTOR LESSON PLANS
30. COMPLETE INSTRUCTOR LESSON PLANS
31. START PRESENTATIONS
32. COMPLETE PRESENTATIONS
HEALTH AND SAFETY
33. START TRAINING STANDARDS
34. COMPLETE TRAINING STANDARDS
35. START SYLLABUS
36. COMPLETE SYLLABUS
37. START STUDY GUIDES VISUAL AIDS
38. COMPLETE STUDY GUIDES/ VISUAL AIDS
39. START INSTRUCTOR LESSON PLANS
40. COMPLETE INSTRUCTOR LESSON PLANS
41. START PRESENTATIONS
42. COMPLETE PRESENTATIONS
43. ON-THE-JOB AND FACTORY TRAINING
44. PERSONNEL QUALIFICATION PROCEDURES

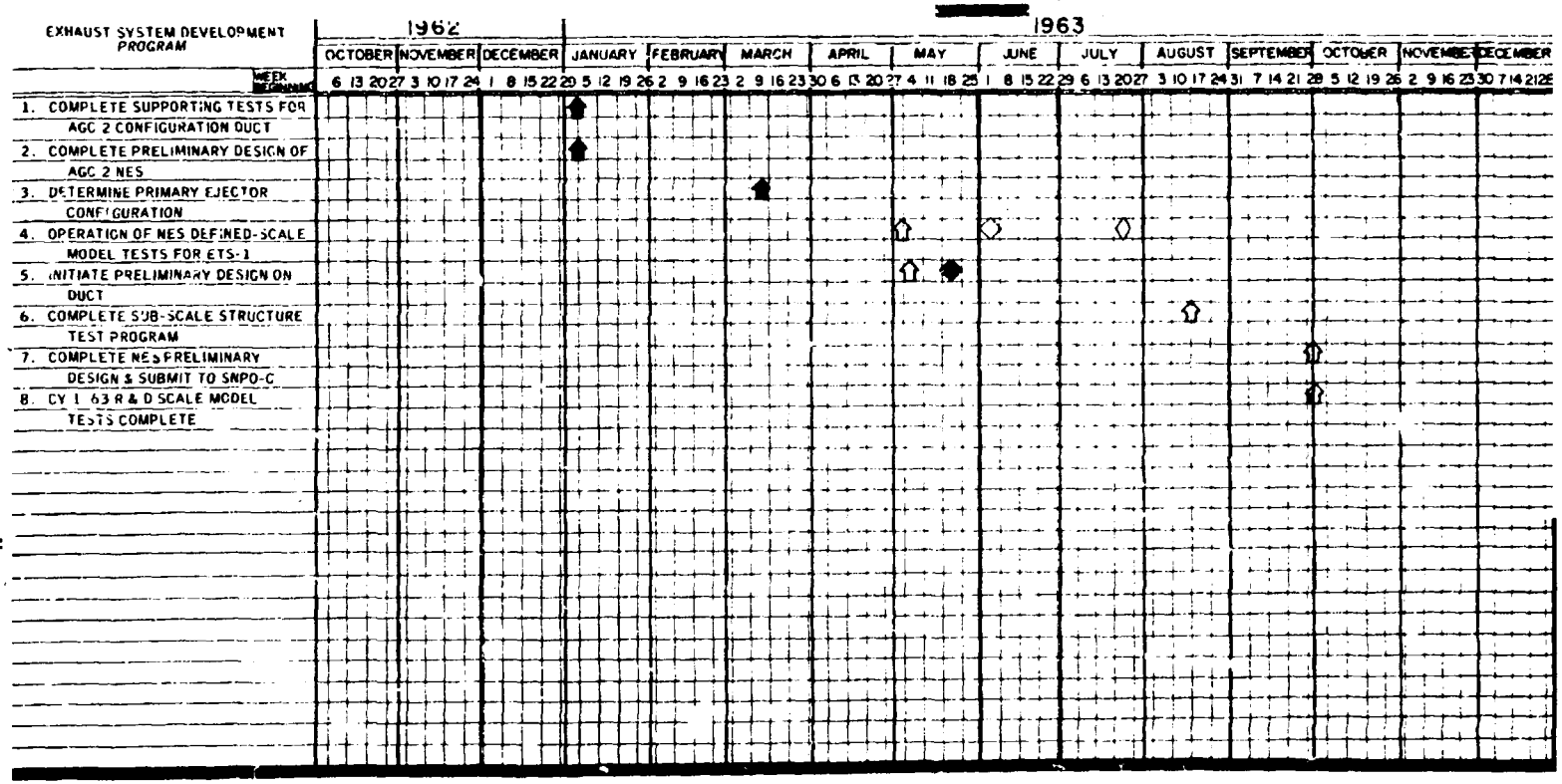
DATE

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 3.1

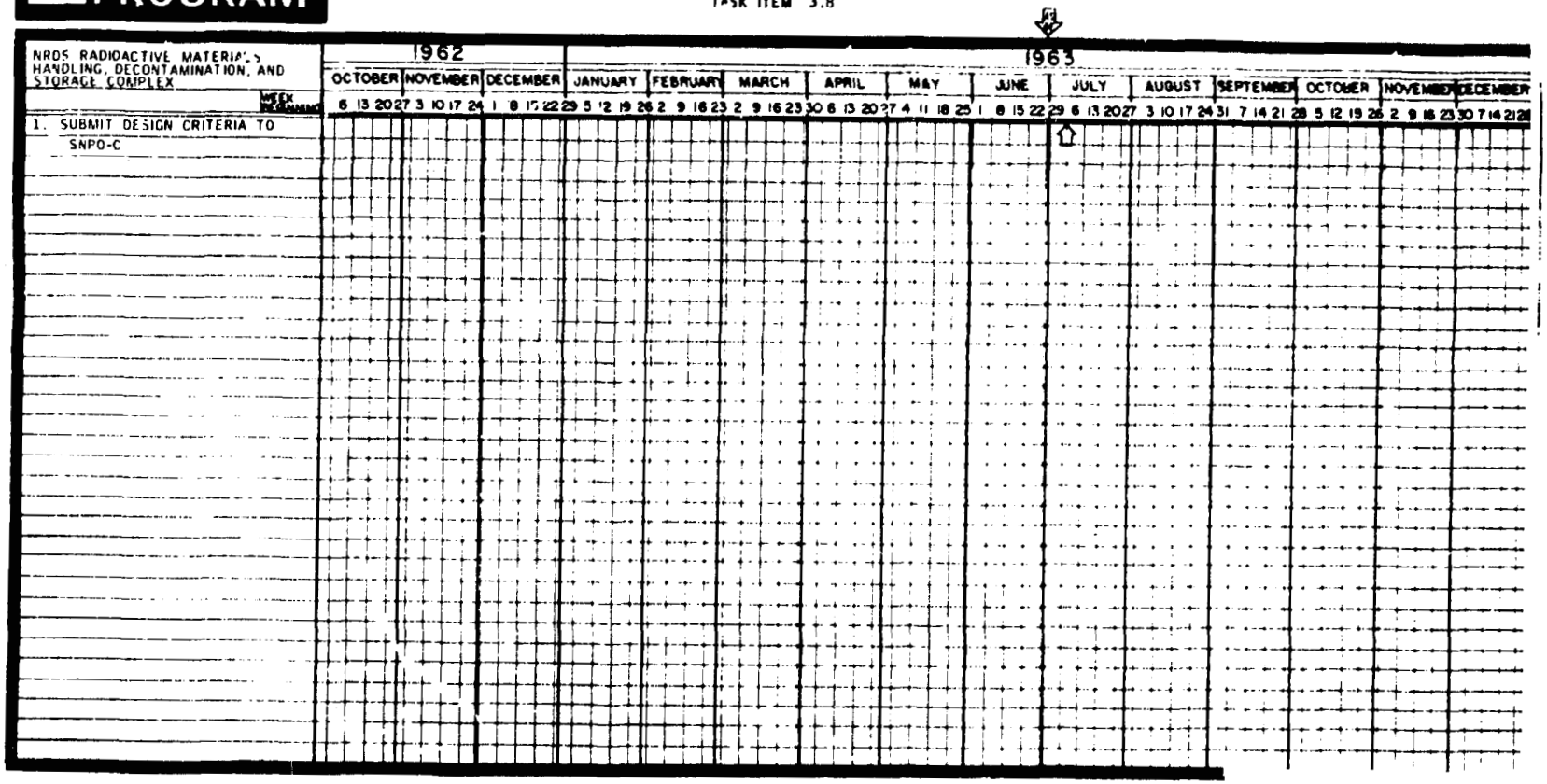

EXHAUST SYSTEM DEVELOPMENT PROGRAM
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK BEGINNING
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. COMPLETE SUPPORTING TESTS FOR AGC 2 CONFIGURATION DUCT
2. COMPLETE PRELIMINARY DESIGN OF AGC 2 NES
3. DETERMINE PRIMARY EJECTOR CONFIGURATION
4. OPERATION OF NES DEFINED-SCALE MODEL TESTS FOR ETS-1
5. INITIATE PRELIMINARY DESIGN ON DUCT
6. COMPLETE SUB-SCALE STRUCTURE TEST PROGRAM
7. COMPLETE NES PRELIMINARY DESIGN & SUBMIT TO SNPO-C
8. CY 1 63 R & D SCALE MODEL TESTS COMPLETE

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 3.8


NRDS RADIOACTIVE MATERIALS HANDLING, DECONTAMINATION, AND STORAGE COMPLEX
WEEK BEGINNING
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. SUBMIT DESIGN CRITERIA TO SNPO-C

DATE:

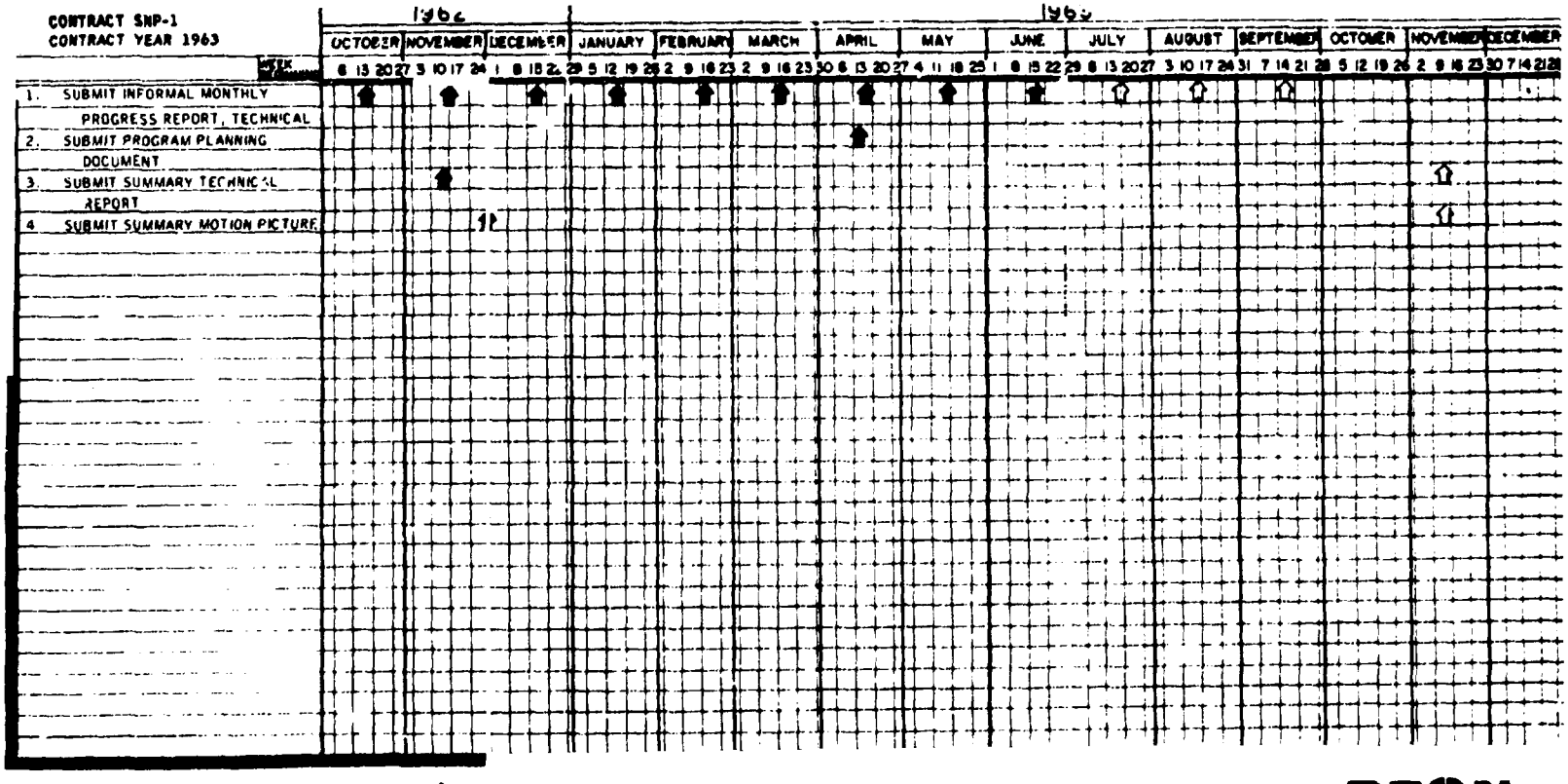
⇧ SCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 54 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 4.3
ADDITIONAL DOCUMENTATION


CONTRACT SNP-1
CONTRACT YEAR 1963
1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK ENDING
1. SUBMIT INFORMAL MONTHLY PROGRESS REPORT, TECHNICAL
2. SUBMIT PROGRAM PLANNING DOCUMENT
3. SUBMIT SUMMARY TECHNICAL REPORT
4. SUBMIT SUMMARY MOTION PICTURE

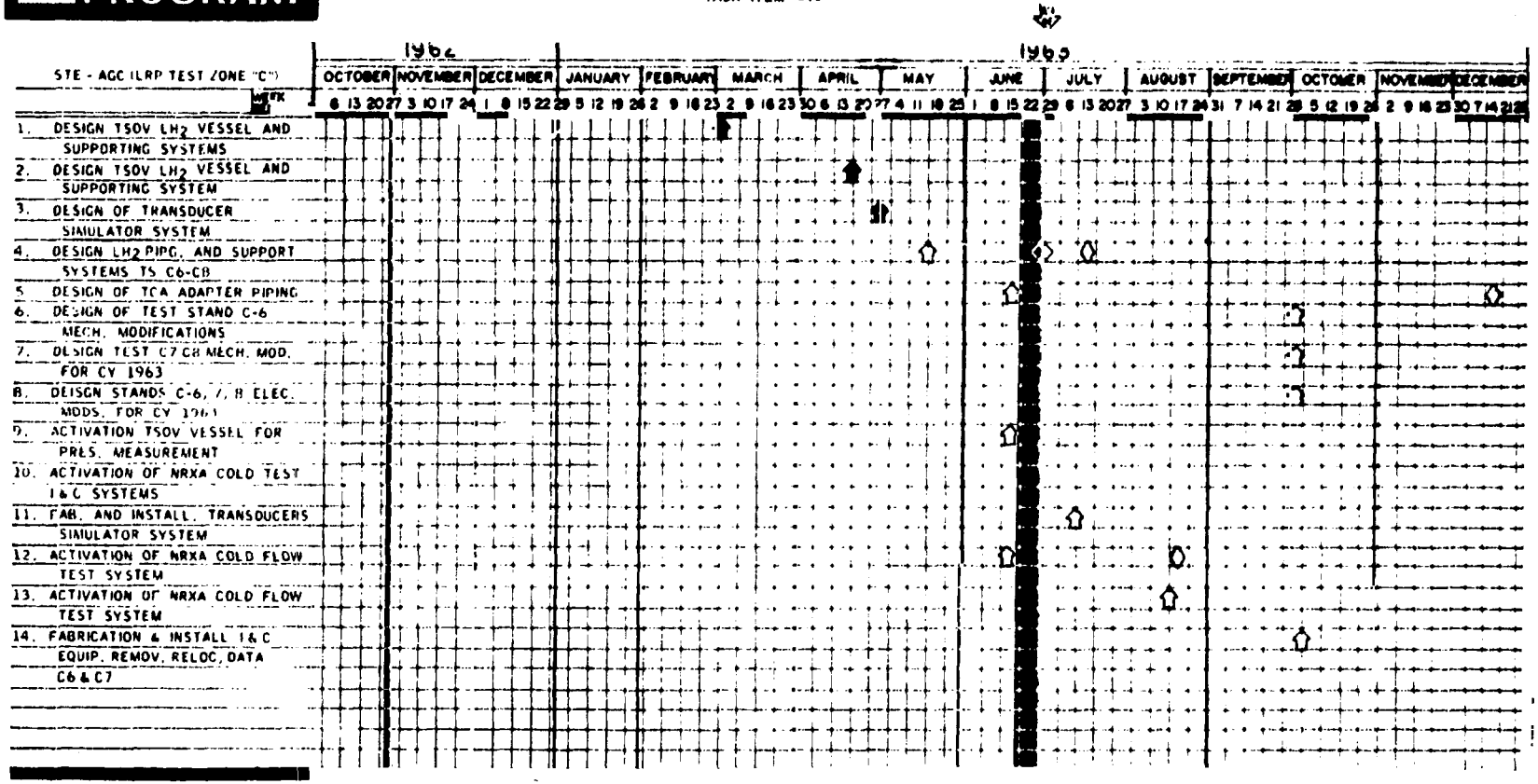
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
● RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 55 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.1


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
STE - AGC (LRP TEST ZONE "C")
1. DESIGN TSOV LH2 VESSEL AND SUPPORTING SYSTEMS
2. DESIGN TSOV LH2 VESSEL AND SUPPORTING SYSTEM
3. DESIGN OF TRANSDUCER SIMULATOR SYSTEM
4. DESIGN LH2 PIPG. AND SUPPORT SYSTEMS TS C6-C8
5. DESIGN OF TCA ADAPTER PIPING
6. DESIGN OF TEST STAND C-6 MECH. MODIFICATIONS
7. DESIGN TEST C7 C8 MECH. MOD. FOR CY 1963
8. DEISGN STANDS C-6, 7, 8 ELEC. MODS. FOR CY 1963
9. ACTIVATION TSOV VESSEL FOR PRES. MEASUREMENT
10. ACTIVATION OF NRXA COLD TEST I & C SYSTEMS
11. FAB. AND INSTALL. TRANSDUCERS SIMULATOR SYSTEM
12. ACTIVATION OF NRXA COLD FLOW TEST SYSTEM
13. ACTIVATION OF NRXA COLD FLOW TEST SYSTEM
14. FABRICATION & INSTALL I & C EQUIP. REMOV. RELOC. DATA C6 & C7

DATE:

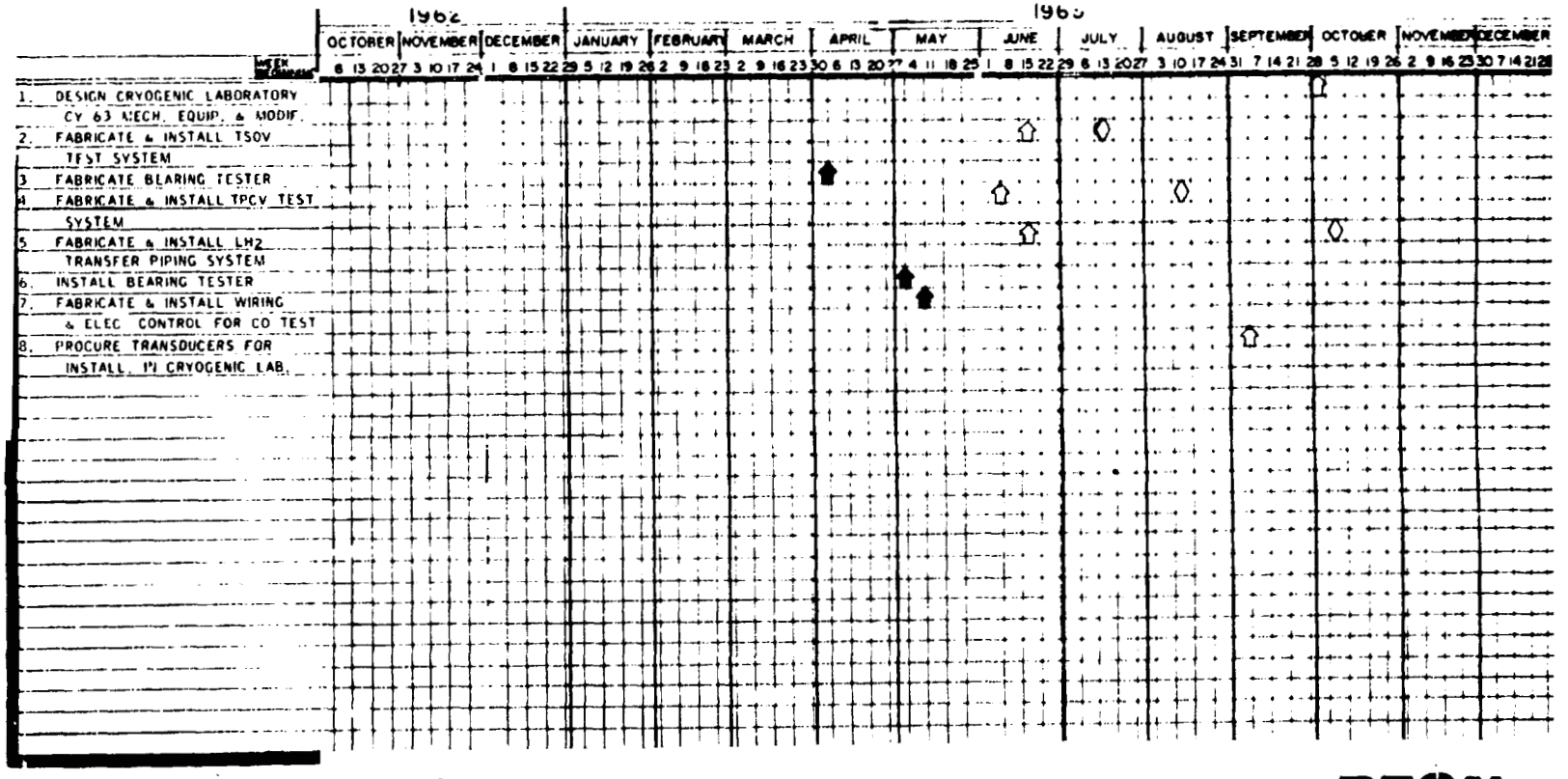
⇧ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬆ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 56 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.2



DATE:

⬠ SCHEDULED MILESTONE
◇ RESCHEDULED MILESTONE
⬟ MILESTONE ACHIEVEMENT
◆ RESCHEDULED MILESTONE ACHIEVEMENT

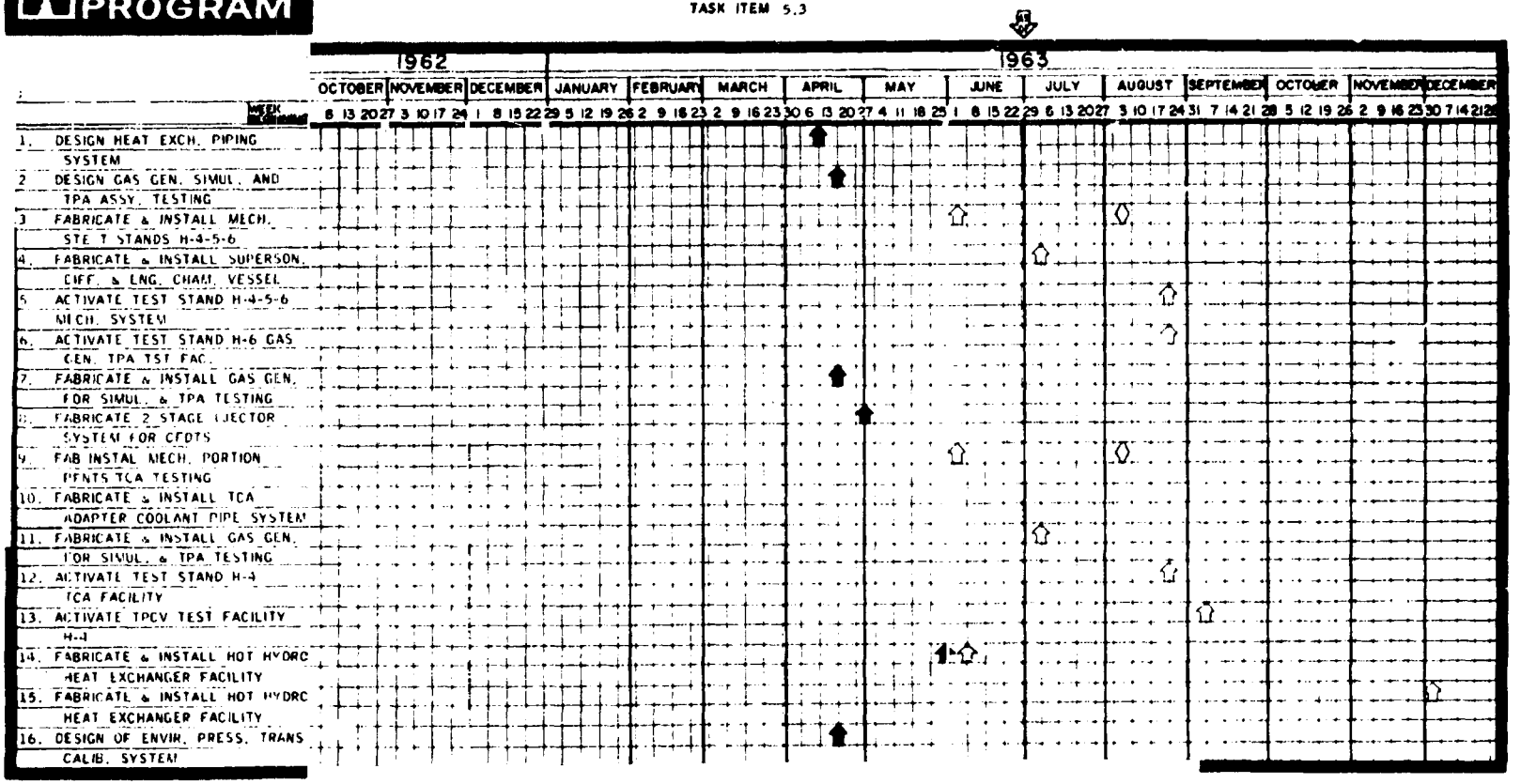
Figure 1
Sheet 57 of 63

REON

NERVA PROGRAM

CONTRACT YEAR 1963

TASK ITEM 5.3


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
WEEK ENDING
8 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. DESIGN HEAT EXCH. PIPING SYSTEM
2 DESIGN GAS GEN. SIMUL. AND TPA ASSY. TESTING
3 FABRICATE & INSTALL MECH. STE T STANDS H-4-5-6
4. FABRICATE & INSTALL SUPERSON. DIFF. & LNG. CHAM. VESSEL
5 ACTIVATE TEST STAND H-4-5-6 MECH. SYSTEM
6. ACTIVATE TEST STAND H-6 GAS GEN. TPA TST FAC.
7. FABRICATE & INSTALL GAS GEN. FOR SIMUL. & TPA TESTING
8. FABRICATE 2 STAGE EJECTOR SYSTEM FOR CFDTS
9. FAB INSTAL MECH. PORTION PFNTS TCA TESTING
10. FABRICATE & INSTALL TCA ADAPTER COOLANT PIPE SYSTEM
11. FABRICATE & INSTALL GAS GEN. FOR SIMUL. & TPA TESTING
12. ACTIVATE TEST STAND H-4 TCA FACILITY
13. ACTIVATE TPCV TEST FACILITY H-4
14. FABRICATE & INSTALL HOT HYDRO HEAT EXCHANGER FACILITY
15. FABRICATE & INSTALL HOT HYDRO HEAT EXCHANGER FACILITY
16. DESIGN OF ENVIR. PRESS. TRANS CALIB. SYSTEM

DATE:

⇧ SCHEDULED MILESTONE

◇ RESCHEDULED MILESTONE

⬆ MILESTONE ACHIEVEMENT

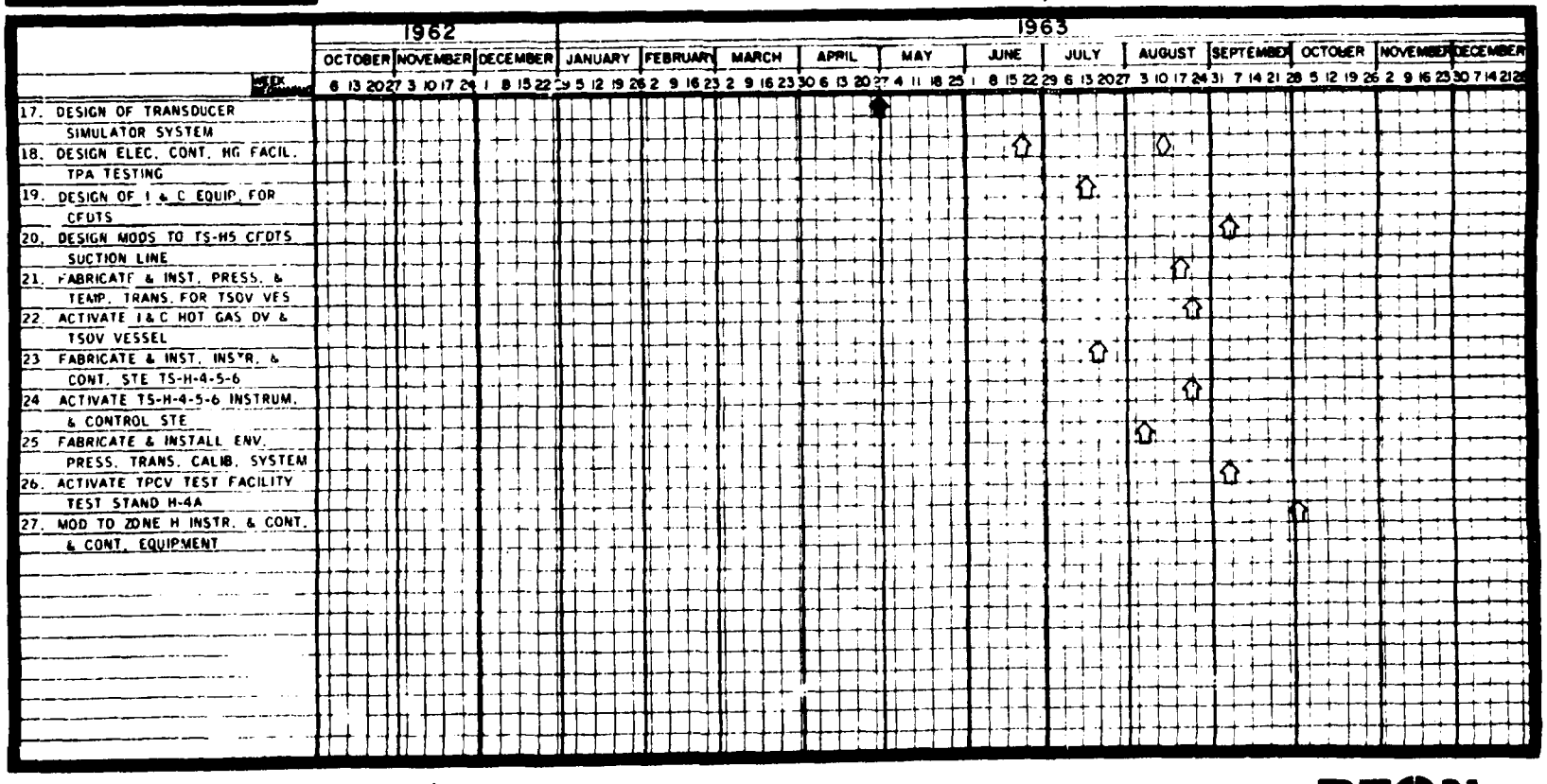
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 58 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.3


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
17. DESIGN OF TRANSDUCER SIMULATOR SYSTEM
18. DESIGN ELEC. CONT. HG FACIL. TPA TESTING
19. DESIGN OF I & C EQUIP. FOR CFDTS
20. DESIGN MODS TO TS-H5 CFDTS SUCTION LINE
21. FABRICATE & INST. PRESS. & TEMP. TRANS. FOR TSOV VES
22. ACTIVATE I & C HOT GAS OV & TSOV VESSEL
23. FABRICATE & INST. INSTR. & CONT. STE TS-H-4-5-6
24. ACTIVATE TS-H-4-5-6 INSTRUM. & CONTROL STE
25. FABRICATE & INSTALL ENV. PRESS. TRANS. CALIB. SYSTEM
26. ACTIVATE TPCV TEST FACILITY TEST STAND H-4A
27. MOD TO ZONE H INSTR. & CONT. & CONT. EQUIPMENT

DATE:

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.4

STE - AGC (AZUSA PLANT)
ANALOG COMPUTER

1962: OCTOBER (6 13 20 27) NOVEMBER (3 10 17 24) DECEMBER (1 8 15 22 29)
1963: JANUARY (5 12 19 26) FEBRUARY (2 9 16 23) MARCH (2 9 16 23 30) APRIL (6 13 20 27) MAY (4 11 18 25) JUNE (1 8 15 22 29) JULY (6 13 20 27) AUGUST (3 10 17 24 31) SEPTEMBER (7 14 21 28) OCTOBER (5 12 19 26) NOVEMBER (2 9 16 23 30) DECEMBER (7 14 21 28)

1. PACE 231R CONSOLE RECEIVED
2. MODERNIZATION PACE 24D COMPLETE
3. MODERNIZATION PACE 131R COMPLETE
4. DELIVER 231R ADDITIONAL EQUIPMENT
5. DELIVER CONTROL SYSTEM C O EQUIPMENT
6. PROTOTYPE THERMAL CONDUCTIVITY EQUIPMENT DEMONSTRATION
7. THERMAL CONDUCTIVITY EQUIPMENT DELIVERED TO GENERAL DYNAMICS FT. WORTH

DATE:

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
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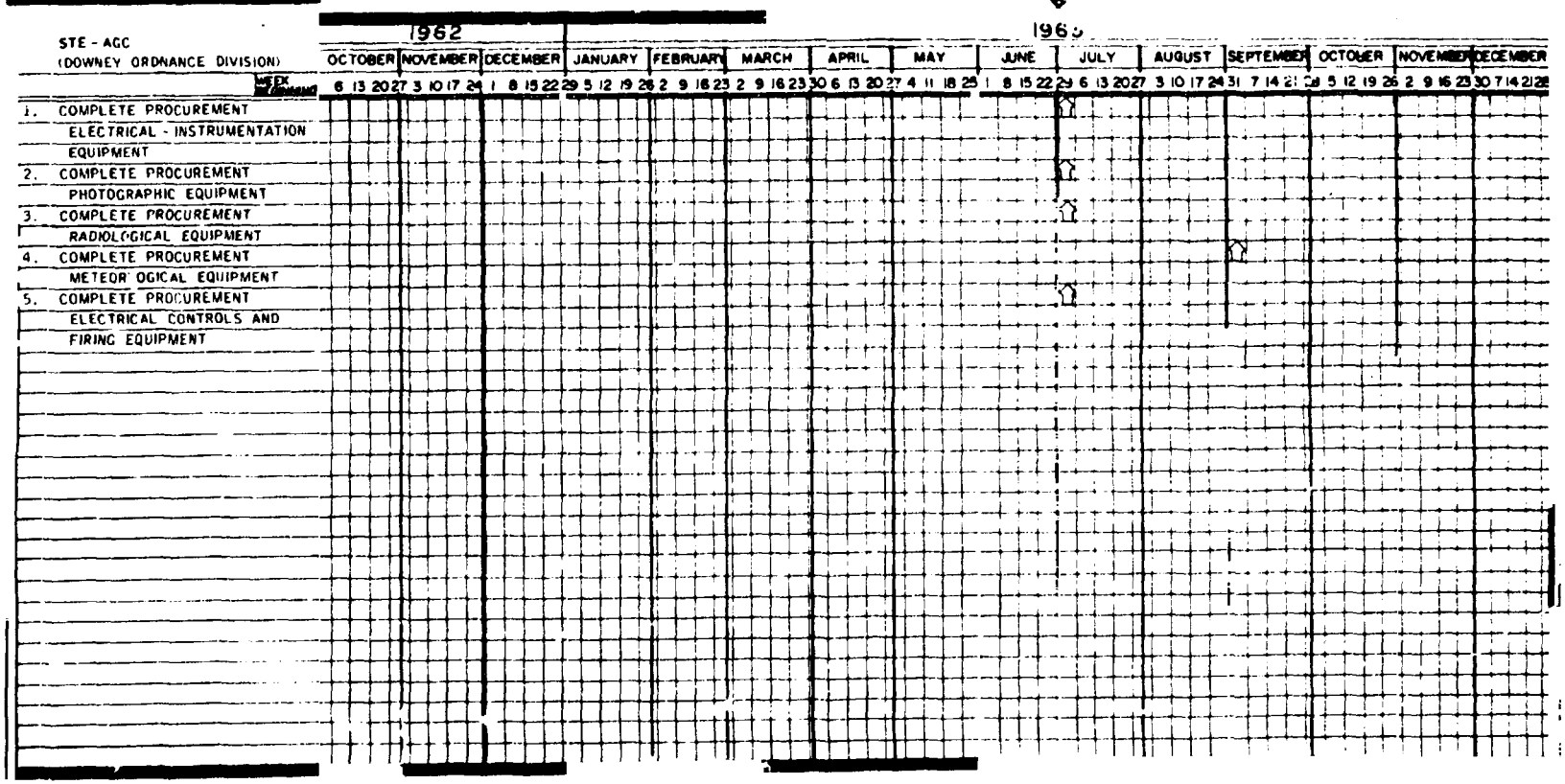
REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.5

STE - AGC
(DOWNEY ORDNANCE DIVISION)


1962
1963
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. COMPLETE PROCUREMENT ELECTRICAL - INSTRUMENTATION EQUIPMENT
2. COMPLETE PROCUREMENT PHOTOGRAPHIC EQUIPMENT
3. COMPLETE PROCUREMENT RADIOLOGICAL EQUIPMENT
4. COMPLETE PROCUREMENT METEOROLOGICAL EQUIPMENT
5. COMPLETE PROCUREMENT ELECTRICAL CONTROLS AND FIRING EQUIPMENT

DATE:

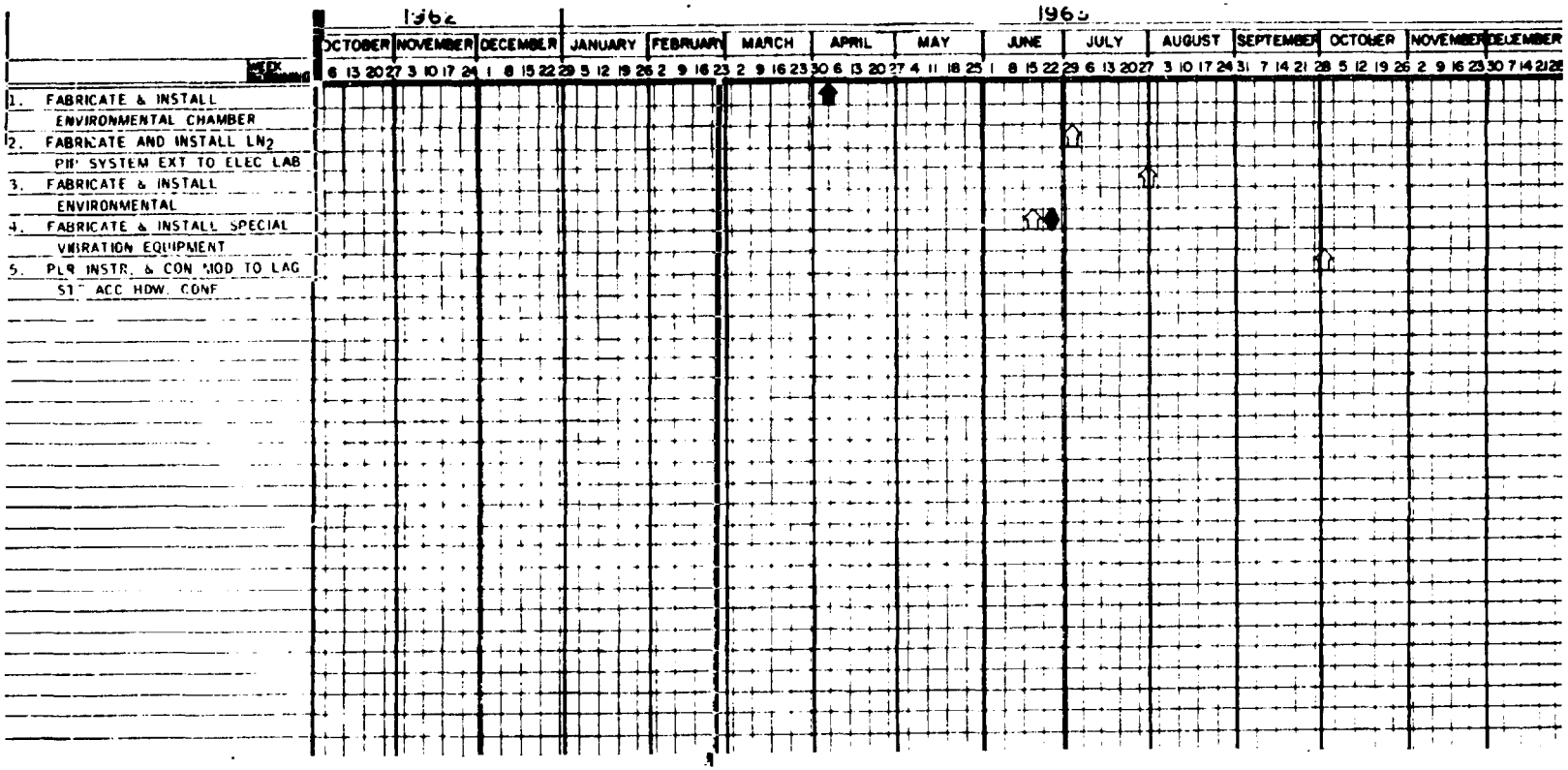
◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 62 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 5.9


1962
1963
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28
1. FABRICATE & INSTALL ENVIRONMENTAL CHAMBER
2. FABRICATE AND INSTALL LN_2 PIP' SYSTEM EXT TO ELEC LAB
3. FABRICATE & INSTALL ENVIRONMENTAL
4. FABRICATE & INSTALL SPECIAL VIBRATION EQUIPMENT
5. PLR INSTR. & CON MOD TO LAG ST' ACC HDW. CONF

DATE:

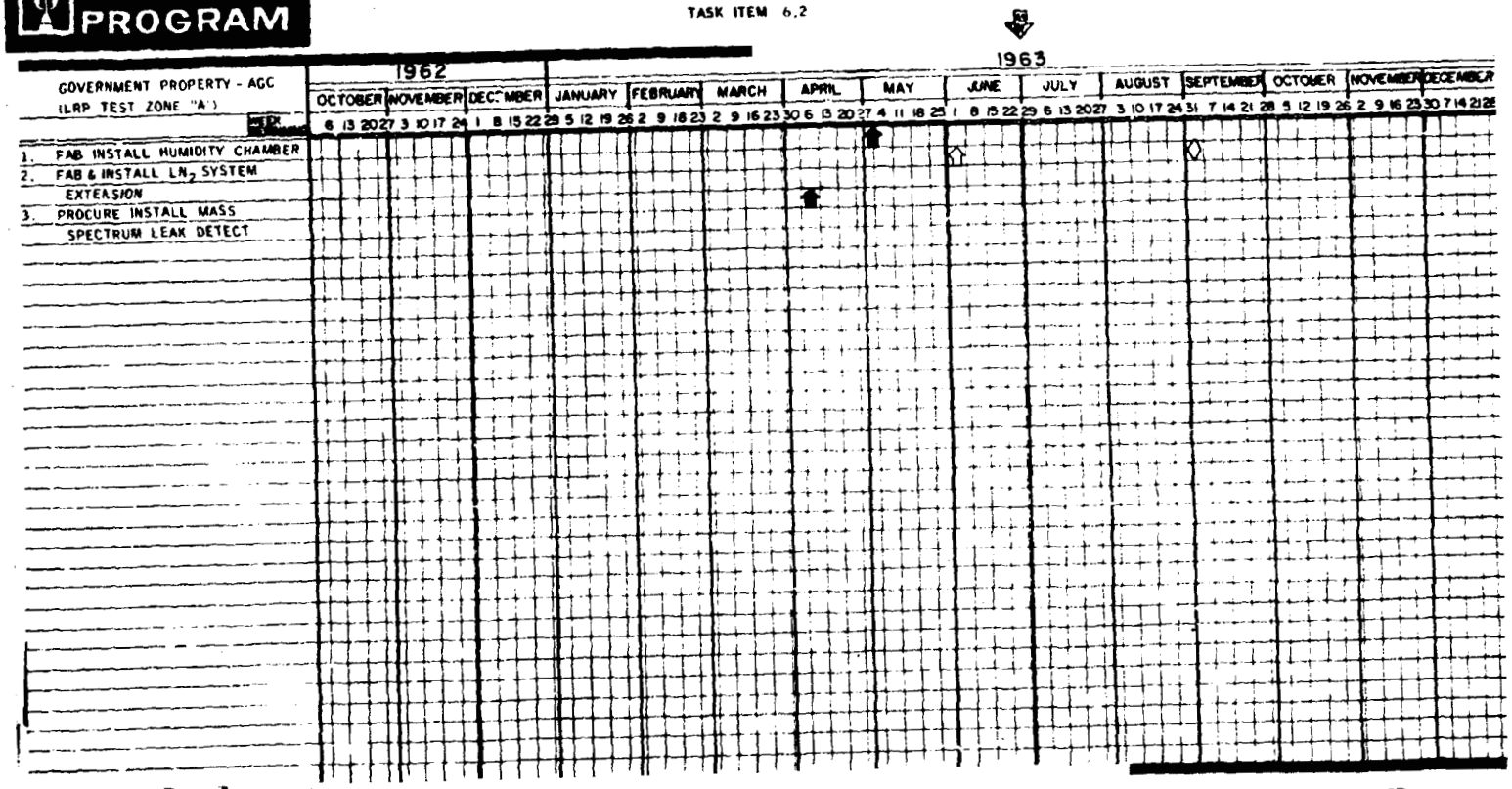
⇧ SCHEDULED MILESTONE
⇩ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 62 of 63

REON

NERVA PROGRAM

SCHEDULES AND MILESTONES
CONTRACT YEAR 1963
TASK ITEM 6.2



DATE:

◇ SCHEDULED MILESTONE
◆ MILESTONE ACHIEVEMENT
◇ RESCHEDULED MILESTONE
◆ RESCHEDULED MILESTONE ACHIEVEMENT

Figure 1
Sheet 63 of 63

REON